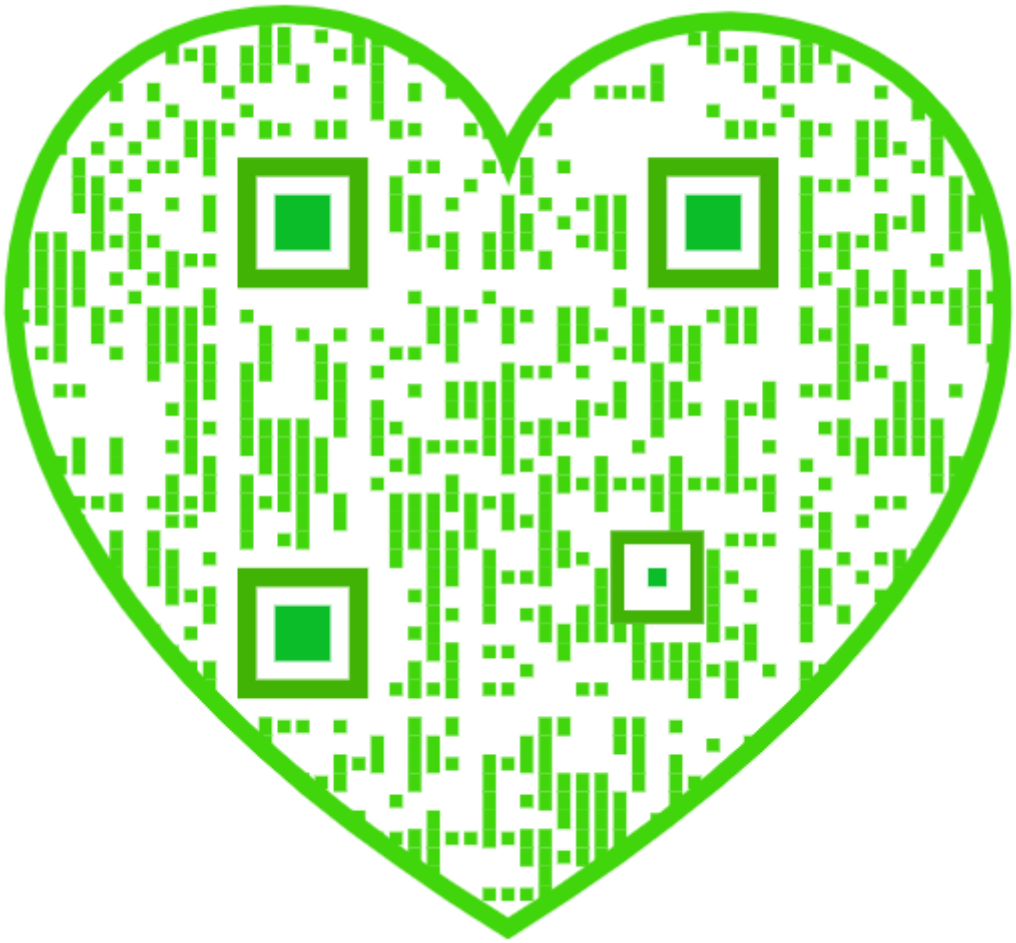

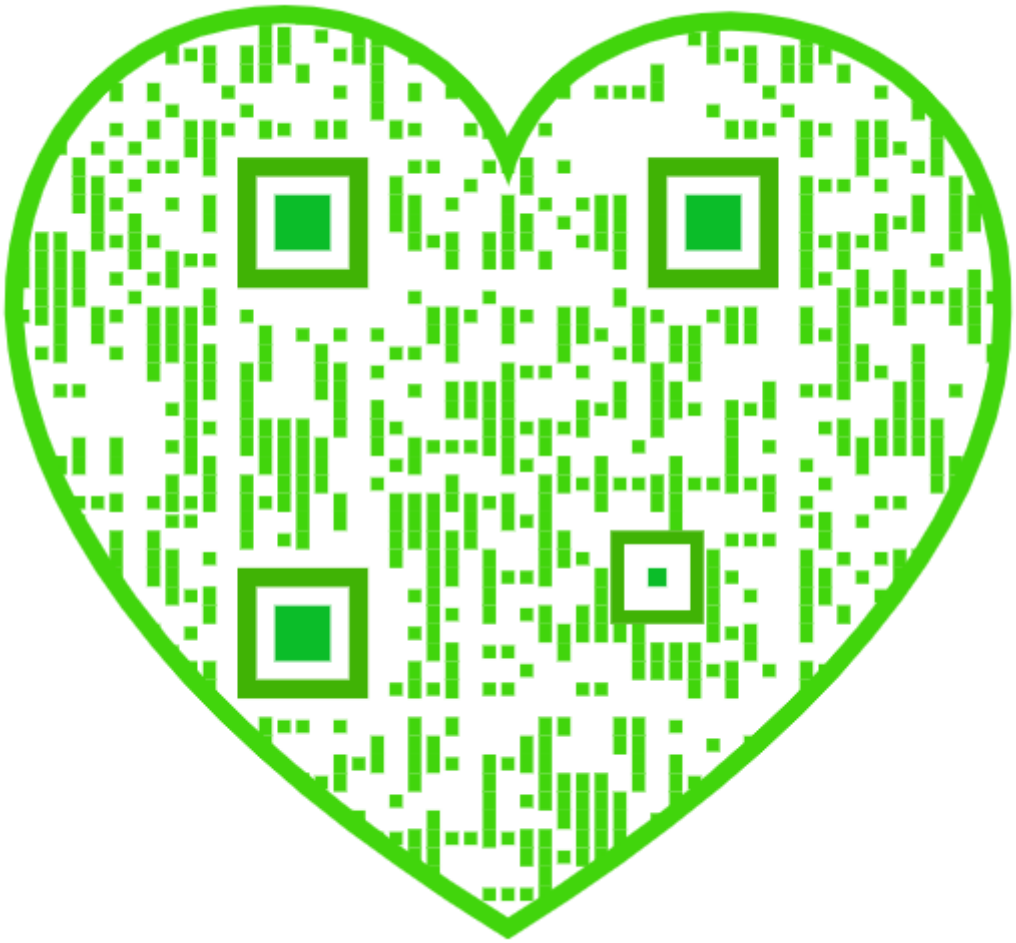

SANITATION IN PANAMA

Concreted Ditch. Ancon.

SANITATION IN PANAMA

BY

WILLIAM CRAWFORD GORGAS

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ILLUSTRATED

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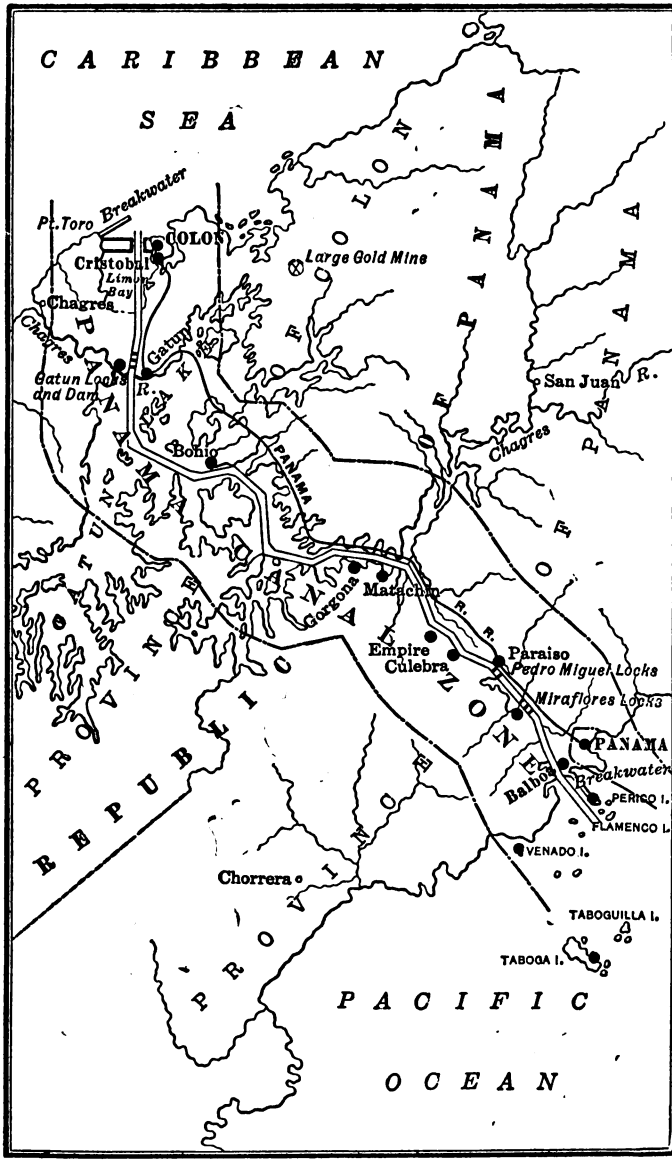


Map of the Panama Canal Zone, Showing Hospitals of the Sanitary Department.

SANITATION IN PANAMA

CHAPTER I

YELLOW FEVER AND THE DISCOVERIES OF ITS TRANSMISSION

YELLOW FEVER for two hundred years before the Spanish-American War caused great loss of life and much destruction of wealth. Every few years portions of the United States would become infected with this disease. In the earlier part of this period the disease was more or less local. As the Mississippi valley became more thickly populated, the extent of the disease and the injury caused became very much augmented. The epidemic of 1878 was probably the deadliest and most extensive epidemic of yellow fever which ever affected the United States. In this epidemic over thirteen thousand people in the Mississippi valley alone lost their lives, and the loss of wealth is estimated at considerably more than one hundred millions of dollars.

It is very difficult to convey to a reader any idea of the conditions which exist during an epidemic of yellow fever. All business is entirely para-

lyzed, the quarantines not allowing any communication between the affected districts and those not affected. In an epidemic of any extent this means hundreds of local quarantines. Some idea of the condition of affairs can be obtained by picturing what would occur in any community if all the income of that community should entirely cease for six months. And this was the condition of business all over the Mississippi valley every time yellow fever gained entrance.

The population originally feared yellow fever on account of the poverty, suffering and business depression always caused by the quarantines which had to be enforced to prevent its spread, and in time people came to associate this idea of dread with yellow fever itself. When this disease was announced in a town, everybody left who could. The sick were frequently left without care, and often a great deal of cruelty and cowardice was shown. If a person escaped from an infected region and became sick with the disease, or sick from any other cause, he was generally treated as if he were a leper, and would often be left to starve or die on the roadside.

It requires continuously warm weather for the yellow-fever mosquito to breed in sufficient numbers to propagate yellow fever; therefore, this disease never became endemic in the United States. I mean by endemic, existing all the year

round and over a number of years. The frosts of winter, wherever they occur, either destroy all the yellow-fever mosquitoes, or reduce their number below the point at which yellow fever could be propagated.

It was known in the United States that yellow fever was always brought somewhere from the littoral of either the Gulf of Mexico, or the Caribbean Sea, and the city of Havana, located on the northern coast of the island of Cuba, was known to be the center of this endemic area.

Yellow fever in 1898 was looked upon as the example of a filth disease, par excellence, and it was thought that if Havana were put in a proper state of cleanliness, it might cease to be the great point of infection for the United States. It was known that yellow fever had existed in the city of Havana continuously for one hundred and fifty years. It is interesting to note that the endemic infection of Havana occurred in 1762, when Havana was besieged and captured by American troops. I say American troops, because the expedition was largely composed of men from the present United States, then colonies of Great Britain. It is also interesting to note that this infection was supposed to have been brought by a vessel from Vera Cruz.

Yellow fever peculiarly affects shipping, and time and again ships in the harbor of Havana

have had every living soul of their crew die from this disease, and these vessels would have to lie there for months until another crew could be obtained.

When we went to Havana in 1898 we knew no more of the sanitation of yellow fever than we had known a century before. The army which went to Santiago suffered as severely from yellow fever and other tropical diseases as any military expedition into the tropics had suffered before that time, and its death rate, had it remained, would have been just as high as was that of the French army of similar size, which was exterminated in the island of Haiti just one hundred years before.

A very deep impression was made upon me by the condition of our army at the end of two months' campaigning in this tropical region. It was utterly used up and of no value whatever as a fighting machine. Fully four-fifths of the men were having fever. This small army of sixteen thousand men was as fine a body of soldiers when they landed at Siboney as could probably be gotten together, but after two months' campaigning in this tropical jungle, and after several weeks of fever from which no one was free, their stamina and morale were completely gone. After the surrender of the Spanish garrison there was a complete let-down on our side. Everybody wanted to

go home. No one could see any need of staying in Cuba, and every individual was perfectly certain that he would die if he remained there a month longer. Officers and men became nervous and hysterical. I commanded the base hospital at Siboney, and it was my disagreeable duty to select from day to day those who would have to remain. Many times every day the poor fellows, officers and men, would break down and cry when told that they could not leave on the next ship. I could form some idea of what it must have been among the French at Haiti when they knew that they could not get away, but had to stay and die.

Being immune to yellow fever, I made application to go with the troops that took possession of Havana. We arrived there in December, 1898. The military authorities concluded that this was the opportunity which the United States had been awaiting for the past two hundred years. Thinking that yellow fever was a filth disease, they believed that if we could get Havana clean enough, we could free it from yellow fever. It was felt that if we could eliminate Havana as a focus of infection, the United States would cease to be subject to epidemics. This meant so much to the United States, financially and otherwise, that the authorities determined to make all other efforts secondary to this sanitary effort.

The city was cleaned as well as it was possible

to cleanse it. This remark applies as well to the private premises as to the public highways. Energetic and capable Army officers were placed at the head of various municipal departments, and these departments were thoroughly organized and made as efficient as possible. By the middle of the year 1900 all the city governments were perfectly organized, and were accomplishing all that it was possible for them to accomplish. I believe that Havana was cleaner than any other city had ever been up to that time.

The health regulations of the Sanitary Department, such as the isolation and care of yellow-fever patients, were thoroughly and carefully carried out. But in spite of all this work and care, yellow fever had been steadily growing worse ever since we had taken possession of the city, and in 1900 there were a greater number of cases than there had been for several years. The Cubans twitted us with the fact that all our cleaning up and expenditure not only had not bettered things, but had even made them worse. They called attention to the fact that the very cleanest and best kept portions of the city were by far the worst sufferers from yellow fever, and the evidence was so staringly before our eyes that we had to acknowledge the truth of what they said.

The health authorities were at their wits' end. We evidently could not get rid of Havana as a

focus of infection by any method we then knew.

A few years before this period, an Italian savant had announced in Brazil that he had discovered the organism which caused yellow fever. This organism was known as the bacillus icteroides of Sanarelli, and it was quite generally accepted that Sanarelli had proved this to be the causative agent in yellow fever.

Drs. Reed and Carroll had proved that the bacillus icteroides of Sanarelli was identical with the hog-cholera bacillus. They made this demonstration while comparing the bacillus X of Sternberg with the bacillus icteroides of Sanarelli. The work was carried on by them during the years 1897 and 1898, at the laboratory of the Army Medical Museum in Washington. The investigation was undertaken at the request of General Sternberg.

In 1899 our Public Health Service published the report of a board of medical officers who had been sent to Havana to investigate Sanarelli's organism. This report made a great impression. Surgeon-General Wyman, in his letter transmitting the report says:

The findings of this Commission, verifying the discovery made by Sanarelli, and making still further advances than did Sanarelli himself by determining the specificity of the bacillus icteroides, and that the primary infection of yellow fever is

received through the respiratory tract, in other words, verifying one discovery and making others of almost equal importance, at the same time eliminating incorrect theories, must be considered a notable achievement in medical science and one of the greatest practical value to the people of the United States and other countries infected, or liable to be infected by yellow fever.

. . . . . .

In view of the widespread interest which the report will excite and the practical deductions to be drawn therefrom, I have respectfully to request authority to have the same printed.

The findings of this Commission were:

First. That the microörganism discovered by Professor Giuseppi Sanarelli, of the University of Bologna, Italy, and by him named "bacillus icteroides" is the cause of yellow fever.

Second. That yellow fever is naturally infectious to certain animals, the degree varying with the species; that in some of the rodents local infection is very quickly followed by blood infection, and that, while in dogs and rabbits there is no evidence of this subsequent invasion of the blood, monkeys react to the infection the same as man.

Third. That infection takes place by way of the respiratory tract, the primary colonization in this tract giving rise to the earlier manifestations of the disease.

Fourth. That in many cases, probably a majority, the primary infection, or colonization, in the lungs is followed by a "secondary infection," or a secondary colonization in the blood of the patient. This secondary infection may be complicated by the coinstantaneous passage of other organisms into the blood, or this complication may arise during the last hours of life.

Fifth. There is no evidence to support the theory advanced by Professor Sanarelli that this disease is primarily a septicemia, inasmuch as cases do occur in which the bacillus icteroides cannot be found in the blood, or organs in which it might be deposited therefrom.

Sixth. That there exists no casual relationship between the bacillus X of Sternberg and this highly infectious disease; and that this bacillus X is frequently found in the intestinal contents of normal animals and of man, as well as in the urine and the bronchial secretion.

Seventh. That, so far as your Commission is aware, the bacillus icteroides has never been found in any body other than of one infected with yellow fever; and that whatever may be the cultural similarities between this and other microörganisms, it is characterized by a specificity which is distinctive.

Eighth. That the bacillus icteroides is very susceptible to the influences injurious to bacterial life,

and that its ready control by the processes of disinfection, chemical and mechanical, is assured.

Ninth. That the bacillus icteroides produces in vitro as well as in vita a train of the most marked potency; and that, from our present knowledge, there exists a reasonable possibility of the ultimate production of an antiserum more potent than that of Professor Sanarelli.

About the same time an officer of the Public Health Service, Dr. H. R. Carter, was making in Mississippi his epoch-marking observations upon the extrinsic incubation of yellow fever. Measured by the results produced, this was one of the most important papers ever written. Yet as high an authority as the Surgeon-General of the Public Health Service expected the greatest results to flow from the conclusions reached by this Board, and did not notice the report from his subordinate concerning the extrinsic incubation of yellow fever. The conclusions of his Board turned out to be all wrong and useless as to results. The report of Carter turned out to be pure gold, and was one of the great steps in establishing the true method of the transmission of yellow fever. I do not say this in criticism. It is almost impossible for contemporaries to judge the true value of discoveries, or to give the proper position to the men of their own time who make these discoveries.

General George M. Sternberg, the then Surgeon-

General of the Army, was one of the leading bacteriologists of the profession, and was also one of the best known authorities on yellow fever. He doubted the findings of this Board, and obtained authority from the Secretary of War to appoint a board of Army medical officers to investigate this same subject. He appointed on this now famous and immortal board Reed, Lazear, Carroll and Agramonte. They came to Havana, and spent several months in investigating Sanarelli's organism. They proved beyond peradventure that it had no causative relation to yellow fever, and identified it as a well-recognized organism.

It is an interesting historical fact that one of the yellow-fever patients in whom the Board of Public Health Service found Sanarelli's organism was a patient of mine. He was a soldier, Private Patrick Smith, Eighth Infantry, a non-immune living in an infected part of Havana, so that I thought that he ought to be reported as a suspect. The case continued nine days, long enough to convince me clinically that the disease was not yellow fever. The symptoms in a case of yellow fever dying on the ninth day are always so well marked that the diagnosis should not be in doubt. But the Board found Sanarelli's organism, and being themselves convinced that this was the organism of yellow fever, they believed the case to be that disease. It shows the necessity in scientific mat-

ters of being on one's guard, and of approaching investigation with an open mind.

The Army Board having satisfied themselves that Sanarelli's organism bore no relation to yellow fever, but was simply the ordinary hog-cholera bacillus, turned their attention to other matters, though they were always working in relation to yellow fever. They spent a great deal of time in examining the intestinal flora in cases of recognized yellow fever, but could find nothing that seemed to have any relation to this disease in a causative sense.

Being at that time the health officer of the city of Havana, and in that capacity having charge of all cases of yellow fever which occurred in the city, I necessarily came in contact with this Board a great deal, and with its various members. I was naturally much interested in the work, and kept in very close touch with it. The Sanitary Department of Havana had a commission of medical men to whom all cases of yellow fever were referred for diagnosis. I was a member of this Commission, and Dr. Carlos Finlay, Dr. Antonio Albertini and Dr. John Guiteras were the other members. Each of us had had a very large practical experience with yellow fever. It is likely, therefore, that our Commission was as accurate in its diagnosis of this disease as it was possible for fallible doctors to be. Most of Dr. Reed's experimental cases

were seen and passed upon by this Commission. Dr. Reed requested us to do so, in order that the diagnosis of his cases might be upon the same footing as the diagnosis of the other cases occurring in the city of Havana.

Dr. Carlos Finlay, of Havana, the physician just mentioned as being a member of our Commission, had ever since the year 1881 been investigating, thinking of and writing about the relation of the mosquito to yellow fever. He had convinced himself that this insect was the means whereby the disease was conveyed from person to person. Others before Dr. Finlay's time had referred to the possibility of this being the case, notably Dr. J. C. Nott, of Mobile, Alabama. In March, 1848, he published in the *New Orleans Medical Journal* an article in which he maintained that the spread of yellow fever could not be explained by the assumption of a diffusible miasm in the atmosphere. But Dr. Finlay had given more attention to this subject than anyone who had gone before him. He had written upon it constantly from the year 1881. His argument from the then known facts with regard to yellow fever, showing from these facts that it was probably the mosquito that conveyed this disease, was most beautiful and logical. But a still more beautiful piece of reasoning was the induction that it was the stegomyia mosquito, out of the six or

seven hundred species of mosquitoes, that conveyed yellow fever.

Dr. Finlay, in the twenty years before we went to Havana, had done a great deal of experimenting on the human subject with regard to yellow fever. But he had not been successful in transmitting the disease. He had no means of knowing that it took the mosquito twelve days from the time when she swallowed the blood of a yellow-fever patient to become herself infectious. Not knowing this fact, it was perfectly natural for Dr. Finlay to use his mosquitoes upon his experimental cases within the first four or five days after they had bitten a yellow-fever patient. At any rate, in a large number of experimental bitings of the human subject he did not have a single case in which the evidence was conclusive that yellow fever had been conveyed by the mosquito. Reed says of Finlay: "To Dr. Carlos Finlay, of Havana, must be given, however, full credit for the theory of the propagation of yellow fever by means of the mosquito, which he proposed in a paper read before the Royal Academy in that city at its session on the 14th day of August, 1881."

The Reed Board, after many months of inconclusive work in other directions, turned their attention to Dr. Finlay's mosquito theory. Dr. Reed discussed the matter with Dr. Finlay a good deal before he commenced his mosquito work, and

was thoroughly familiar with Dr. Finlay's arguments and ideas on the subject. Indeed, we all knew Dr. Finlay well, but were rather inclined to make light of his ideas, and none more so than I. He and I met every day on the yellow-fever Commission above referred to, and it is probable that every day for more than a year we had more or less discussion on this subject.

Dr. Finlay is a most lovable man in character and personality, and no one could be constantly thrown with him as I was daily for several years without becoming warmly attached to him and forming the highest estimate of his scientific honesty and straightforwardness. Being very familiar with yellow fever, both historically and clinically, I was constantly bringing to his notice instances in the past which could not be accounted for on the mosquito theory. He, with the greatest ingenuity, was equally ready to explain how the mosquito theory could be turned so as to meet just this condition.

Dr. Finlay is still living in retirement and comfortable old age in the city of Havana. When the American forces were withdrawn from Cuba in 1902, Dr. Finlay succeeded me as health officer under the Cuban Government. He has since been retired on a pension by that Government. I called on him in Havana several years ago, and found him enjoying his more than eighty years of age,

and the honors that were being heaped upon him. He is one of the few great men who has had his work recognized during his lifetime.

Dr. Reed got from Dr. Finlay the eggs from which he raised the mosquitoes used in his experimental work. Dr. Finlay says on page 1 of his "Agreement between the History of Yellow Fever and Its Transmission by the Culex Mosquito": "The experiments made by Drs. Reed, Carroll, Agramonte and Lazear were started in June, 1900, with a brood hatched from eggs of the identical insect which at Dr. Lazear's request I had handed to him. All the successful experiments have hitherto been made with that particular mosquito."

Dr. Reed says in his paper, "The Etiology of Yellow Fever, Preliminary Note": "We here desire to express our sincere thanks to Dr. Finlay who accorded us a most courteous interview and has gladly placed at our disposal his several publications relating to yellow fever, during the past nineteen years; and also for ova of the species of mosquito with which he had made his several inoculations. An important observation to be here recorded is that according to Finlay's statement, thirty days prior to our visit, these ova had been deposited by a female just at the edge of the water in a small basin, whose contents had been allowed to slightly evaporate; so that these ova were at

the time of our visit, entirely above contact with the water. Notwithstanding this long interval after deposition, they were promptly converted into the larval stage, after a short period, by raising the level of the water in the basin. With the mosquitoes thus obtained we had been able to conduct our experiments. Specimens of this mosquito forwarded to Mr. L. O. Howard, Entomologist, Department of Agriculture, Washington, D. C., were kindly identified as culex fasciatus—Fabr."

CHAPTER II

THE EXPERIMENTS OF THE REED BOARD

AFTER consultation, the Reed Board determined to experiment to see whether the mosquito really did convey yellow fever. But it was necessary to have a good deal of money and sufficient authority before starting in. The Board had come to Cuba for entirely different investigations, and had not been supplied with sufficient funds for these experiments. Fortunately for the cause of science and of humanity, we had as Governor-General of Cuba at that time General Leonard Wood, of the United States Army. General Wood had been educated as a physician, and had a very proper idea of the great advantages which would accrue to the world if we could establish the fact that yellow fever was conveyed by the mosquito, and his medical training made him a very competent judge as to the steps necessary to establish such fact.

General Wood during the whole course of the

investigations took the greatest interest in the experiments, and assisted the Board in every way he could. Dr. Reed outlined to General Wood the course he expected to pursue, and General Wood was so convinced by Dr. Reed's argument that he authorized the expenditure from Cuban funds of a sufficient sum and gave Dr. Reed ample powers as to the method of expenditure.

The Board then went to work in earnest along lines which seemed calculated to develop the facts in the matter. They started a laboratory at Camp Columbia, the American military station a short distance out of Havana. Here they bred their mosquitoes from eggs procured from Dr. Finlay, and here the first three experimental cases occurred. The first case was severe; the second case was that of Dr. Carroll, a member of the Board, and was well marked, and Dr. Lazear, another member of the Board, died of the disease. Dr. Lazear visited Las Animas Hospital and was bitten by the mosquito on September 13, 1900; was taken sick September 18th and died September 25th. Previously on August 16th, he had been experimentally bitten by a mosquito which had ten days before bitten a yellow-fever patient in the fifth day of the disease. We know now that ten days is too short a time for incubation in the mosquito, and the fifth day a period too late for the yellow-fever patient to be infectious.

Dr. Carroll was intentionally bitten. Dr. Lazear told me after he was taken sick, and a day or two before he died, that he recalled being bitten by a stegomyia three or four days before he was taken sick, and while he was at work at Las Animas, our yellow-fever hospital in Havana. He said that he had noticed the mosquito enough to recognize that it was a stegomyia, and had allowed it to fill and fly away without disturbing it. These three cases satisfied the Board that the stegomyia mosquito was the means of conveying yellow fever, but they determined that they would make such a demonstration of the matter that there could be no doubt in the mind of any reasonable person as to what had been proved.

With this idea in view they selected a spot a mile or more from the military camp, which was well isolated and had no habitations near it. They agreed that if they established an experimental station here and kept their patients in such a way that there was no possibility of their getting out and contracting the disease elsewhere, then the results obtained in this station would be due to measures taken there. They already had their stegomyia mosquitoes which they had reared from the eggs procured from Dr. Finlay. These mosquitoes they took to the hospitals in Havana, and allowed them to bite people sick with yellow fever. In the course of time the Board found that the

mosquito to become infected with this disease must bite the sick human being within the first three days of his disease. This was a singular and unexpected phenomenon, and is explained in this way. The mosquito injects the yellow-fever parasite into the blood of the human being; these parasites at once commence ejecting toxins into the blood in which they are circulating; these toxins irritate the human cells with which the poisoned blood comes in contact and they begin to throw into the blood circulation antitoxins. By the end of the third day these antitoxins have become so concentrated in the blood that they always kill the yellow-fever parasite, and after the third day no yellow-fever parasites remain in the human body.

Yellow fever is a very fatal disease, and on the average kills the patient on the sixth or seventh day. Why then does death occur in yellow fever if on the average the patient lives to the sixth or seventh day, and yet always by the end of the third day the yellow-fever parasites have been routed and destroyed in the great battle which has taken place between them and the body cells?

Dr. Reed established this fact by finding that mosquitoes which had bitten a patient more than three days after the patient had developed yellow fever, did not convey the disease to the non-im-

mune when he attempted to infect these non-immunes with such mosquitoes. On the other hand, he found that he was almost always able to give these non-immunes yellow fever when he used mosquitoes which had bitten the man sick with yellow fever within the first three days of his symptoms.

We have followed Dr. Reed now up to the point of his having infected mosquitoes and being ready to transmit the disease to non-immune human beings. A human being, in order that he may be liable to yellow fever, must be non-immune, and by immune I mean a person who either has had yellow fever, or has lived ten or more years in a locality where yellow fever prevails. An attack of yellow fever gives a great immunity to the disease, probably just as much as occurs in the case of smallpox. In practice, it is counted as absolute. In over two thousand cases of yellow fever which I have treated personally or seen in consultation, I have never seen a single case with a second attack, in which I saw the same individual in the first attack. I have seen several, however, who believed that they had had a previous attack, and I myself believe that I saw them in their second attack. I have by no means seen a quarter as many cases of smallpox as I have of yellow fever, yet I have seen more cases of second attacks of smallpox than I have of yellow fever. I feel con-

fident, therefore, in stating that yellow fever gives fully as great immunity as does smallpox.

It is well known that in a yellow-fever endemic center such as was Havana during the nineteenth century native Havanese are not liable to yellow fever. They look upon their immunity as being absolute, and in my experience of fourteen years of life in such endemic centers I am inclined to accept their belief. The immunity of the native is explained by saying that he has probably had yellow fever in childhood when the disease was very mild, and that, at the time, it was overlooked and not recognized. This is the best explanation that, so far as I know, can be made of the facts in the case.

Certain it is that one of these endemic centers from which yellow fever has been banished for a number of years may have yellow fever as badly as a city in which it has never been endemic. Eighty years ago a native of Mobile, Alabama, or Pensacola, Florida, looked upon himself as being as immune to yellow fever as did the Havanese twenty years ago. But at the present time the native of either of these cities is just as liable to yellow fever as is the man from New York. This is explained by the fact that eighty years ago they had yellow fever so frequently in Mobile and Pensacola that all the natives had this disease in childhood. Within the last fifty years they have

had it so infrequently that very few now living in those cities have had this disease.

Another phase of the same condition is seen in Ecuador. Guayaquil, the port of Ecuador, is located on Guayas River at sea level, not more than three degrees from the equator. Here yellow fever always prevails, and the native of Guayaquil is not liable to the disease and never has it. Quito, the capital of Ecuador, is situated about two hundred miles away, right on the equator, and on the great Andean plateau ten thousand feet above sea level. The stegomyia cannot breed at Quito, so that yellow fever has never occurred there. The native of Quito, therefore, has no immunity to yellow fever, and of this he is well aware. Guayaquil is the only seaport of Ecuador, and everyone leaving the country has to leave through this port. Hundreds of the natives of Quito have died of yellow fever contracted by passing through Guayaquil. The man from Quito dreads Guayaquil a great deal more than did the American in the early days fear Panama.

Dr. Reed, therefore, to make his experiments of any value, had to get human beings who had neither suffered from yellow fever itself, nor had lived long enough in an endemic center to acquire immunity. Havana for a number of years had received a considerable Spanish immigration. At the time to which I refer, it amounted to about

twenty thousand a year. These immigrants believed that they were going to have yellow fever, and though they knew that a considerable number of them must succumb during the process, they were anxious to have the disease and be done with it. There was a very general belief among the Spaniards in Havana that a person with what they called "thin blood" as contra-distinguished from a robust, plethoric, full-blooded person, was much more likely to recover from yellow fever. They tried, therefore, with their newly arrived friends, relatives and dependents from Spain to bring about this condition of their blood. They kept them confined in a darkened room and fed them on a very limited diet, and certainly succeeded in rapidly reducing the strong, florid, robust Gallego to a very marked condition of anemia and debility. The Spaniard believed that he thus saved many lives. I was convinced that he thus killed a good many of his friends and dependents.

The newly arrived Spaniard, as soon as he had had yellow fever and could present a certificate of immunity, could command double the wages that he could get before he had the disease. So that when Dr. Reed proposed to some of these men that they should go out to his camp, have a mild case of yellow fever, be well cared for and when recovered be given by him a certificate of immunity, he found no difficulty in getting volunteers, and

when, in addition to that, he promised each man who had the disease a bonus of two hundred and fifty dollars, the service became exceedingly popular.

Dr. Reed had prepared, as I have above mentioned, a very comfortable camp at an isolated point near Camp Columbia, well separated from all other dwellings. This camp was kept under military guard, so that no one could come and go without Dr. Reed's knowledge. Here he placed his non-immune volunteer Spaniards whom he had gotten from Havana, and kept them under observation for two weeks, taking their temperatures every day so as to be sure that they had not contracted yellow fever before they went out to the camp.

At this point he made another important discovery in the mode of yellow-fever propagation. He found that the mosquito herself had to wait from ten to fifteen days after she had bitten a man sick with yellow fever before she herself conveyed the disease. He found that the mosquito for the first week or ten days after she had bitten the yellow-fever patient was entirely harmless though she fed freely on non-immunes. But after the twelfth or fourteenth day she would give the disease to every non-immune whom she bit. I have often seen the non-immune doctors and nurses at Las Animas Hospital put their hands in the jars

where infected mosquitoes were kept during the first seven days of their infection and allow them to draw their fill of blood, for the purpose of feeding them, but they would not think of doing this after the seventh or eighth day. Two of these nurses afterwards contracted yellow fever from allowing mosquitoes to bite them after the twelfth day, and one of them, Miss Mass, died from the disease so contracted.

Dr. Carlos Finlay, in his many experiments on the human being, was unaware of these two facts with regard to the transmission of yellow fever: first, that the mosquito could only become infected by biting a human being within the first three days of his disease; and second, that she could only become infectious, that is, transmit the disease, when some twelve or fourteen days had passed since she had bitten the sick man. Dr. Finlay put a great many of his mosquitoes to the sick man after the third day, and in no case did he apply his mosquito to the non-immune twelve or fourteen days after she had bitten the infected person.

Dr. Henry R. Carter had published a paper on certain observations of his made during the epidemic of 1898 in the neighborhood of Jackson, Mississippi. It had long been known to men practically familiar with yellow fever that, in general, when you took a patient suffering from yellow fever into a house where yellow fever had

not before existed, the people in that house did not at once develop the fever. We explained this by stating that it was due to the fact that the germs of yellow fever went from the patient to favorable grounds for development about the house, and there underwent some development which enabled them to produce the disease in non-immune man. We thought that the dirtier and more unhygienic were the conditions of the house, the more favorable were the conditions for the further development of the germs. Dr. Carter recorded a number of cases where the houses were isolated and the conditions favorable for making the observations, and found that the average time from the introduction of a yellow-fever patient into a house until the first case of yellow fever was contracted in that house, was about seventeen days. These observations were published to the world.

Dr. Reed was greatly impressed by this publication of Dr. Carter's. He reasoned that if it were the mosquito which transmitted the disease, this period of extrinsic incubation must be due to a period of incubation in the mosquito. He says:

We were also much impressed by the valuable observations made at Orwood and Taylor, Mississippi, during the year 1898 by Surgeon Henry R. Carter, U. S. Marine Hospital Service, "A Note on the Interval between Infecting and Secondary Cases of Yellow Fever, etc." (Reprint from *New*

Orleans Medical Journal, May, 1900.) We do not believe that sufficient importance has been accorded these painstaking and valuable data. We observe that the members of the yellow-fever commission of the Liverpool School of Tropical Medicine, Doctors Surham and Meyers, to whom we had the pleasure of submitting Carter's observations, have been equally impressed by their importance. (*British Medical Journal,* Sept. 8, 1900, pp. 656-70.)

The circumstances under which Carter worked were favorable for recording with considerable accuracy the interval between the time of arrival of infecting cases in isolated farmhouses and the occurrence of secondary cases in these houses. According to Carter, "the period from the first (infecting) case to the first group of cases infected at these houses, is generally from two to three weeks."

The house having now become infected, susceptible individuals thereafter visiting the houses for a few hours, fall sick with the disease in the usual period of incubation, one to seven days.

Other observations made by us since our arrival confirmed Carter's conclusions, thus pointing, as it seemed to us, to the presence of an intermediate host, such as the mosquito, which having taken the parasite into the stomach, soon after the entrance of the patient into the non-infected house, was able, after a certain interval, to reconvey the infecting agent to other individuals, thereby converting a non-infected house into an "infected" house. This interval would appear to be from nine to sixteen days (allowing for the period of

incubation) which agrees fairly closely with the time required for the passage of the malarial parasite from the stomach of the mosquito to its salivary glands.

In view of the foregoing observations we concluded to test the theory of Finlay on human beings.

Dr. Reed had, however, been working for some time before he came to these conclusions. His first nine cases bitten between August 11 and August 25, were all unsuccessful. The next two, bitten on August 27 and 31, were positive and were well-marked cases of yellow fever.

But Dr. Reed's work was now brought to a standstill. He found that all his Spaniards were deserting, and that he could get no more for love or money to come to the camp. The work from being much sought had become very unpopular. For some time he was unable to find any good reason for this. The story told in Havana was that the American soldiers, who were doing the guard duty for the camp, had found an old lime kiln in the lower part of the grounds. In this kiln they had placed a lot of bleached old bones, and here they would take the newly arrived Spaniard and darkly insinuate that these were the bones of their predecessors in Dr. Reed's camp, and that if they did not leave before they were bitten by Dr. Reed's mosquitoes, their bones would

soon be bleaching in the same place. It was useless for Dr. Reed to argue and explain. This ocular evidence was too strong for any argument by word of mouth, and Dr. Reed had to give it up.

Our soldiers had seen that the disease was very mild; that the patients while they were in camp had the very best of high living and a mighty good time, and when they left, were presented with a gratification of two hundred and fifty dollars in shining gold coin. They concluded that this was too good for Gallegos, and belonged of right to natural-born Americans. When the Spaniards had decamped, our men came forward and volunteered. Dr. Reed accepted them, and the work went forward.

CHAPTER III

THE DISCOVERIES OF THE REED BOARD

DR. REED wished to make his demonstrations as convincing and spectacular as possible. It was an entirely new idea, and his conclusions excited a great deal of adverse comment and criticism. This theory was so contrary to what most men thought had been their practical experience that it was received with scant consideration.

He had a small frame house built, fourteen by twenty feet, well screened-in with wire netting, so that mosquitoes could not get in or out. This building he had divided into two compartments by a partition extending down the center, made of wire netting, and it was known as the infected mosquito building. It was well ventilated. Most persons at this time believed that in some way the air conveyed yellow fever. Dr. Reed wished to show that this was not the case.

He put two non-immunes in this building, one in each room. These two men breathed exactly

the same air, and had exactly the same surroundings, with one single exception which I will in a moment point out. But they were entirely separated by the wire netting. He let them live and sleep in these rooms for several days, so as to demonstrate that there was no yellow-fever infection in the building. He then put fifteen infected stegomyia in one of the rooms; left the man in this room for thirty minutes, announcing that the room was now infected. He took the man out of this infected room, but left in the other room two men on the other side of the wire netting. He stated that the man who had stayed thirty minutes in the infected room would come down with yellow fever within three or four days, and that the other men, who were only separated from him by wire netting, and who breathed and were surrounded by exactly the same air, would not get sick.

He explained that the only difference between the two rooms was that in the infected room, infection had been brought about by liberating there fifteen stegomyia mosquitoes which had previously bitten patients sick of yellow fever. The man from the infected room was on the afternoon of the same day again placed in this room for twenty minutes, and on the following day he was a third time put in the room for fifteen minutes. On the first visit he was bitten by seven mosquitoes; on

the second, by five; on the third, by three. At the end of the fourth (Christmas) day, Reed showed the man from the infected room down with yellow fever, and the men who had lived and slept in the other room, separated only by wire netting, perfectly well. He called attention to the fact that the only difference in the exposure of these men was that the sick man had been in a room for thirty minutes, with fifteen infected stegomyia mosquitoes. He claimed that this was a demonstration that the female stegomyia mosquito could transmit yellow fever, and that the atmosphere alone could not. Many of the visitors to Dr. Reed's camp were clinically familiar with this disease, and the case was sufficiently marked to be easily recognized by all as being a case of yellow fever.

Dr. Reed then announced that he would disinfect the room so that it would no longer give yellow fever. When it was prepared, he again placed a non-immune in each room, left them there for several days, and they remained perfectly well. He explained that he disinfected the room by simply catching all the stegomyia mosquitoes which he had formerly liberated in the room.

This demonstration made a very profound impression. Many, however, still urged that while it was evident that the female stegomyia mosquito could convey yellow fever, it was equally evident

from the history of epidemics of this disease that it could be and was generally conveyed in other ways, such as soiled clothing, bedding, the bodies of yellow-fever dead, persons sick of the disease, etc.

Dr. Reed had a small house built, made almost air-tight and with scarcely any ventilation. This building was known as the infected-clothing building, and was purposely so constructed as to exclude anything like efficient ventilation. It was placed on the opposite side of a small valley, about eighty yards from the infected mosquito building, and they were both about seventy-five yards distant from the camp proper. Both houses were provided with wire screen windows and double screen doors, so that mosquitoes could be kept without or within the building, as the experimenter might desire.

In this building he placed material obtained from Las Animas, the yellow-fever hospital of the Health Department of Havana; mattresses on which yellow-fever patients had died, soiled by their excreta and discharges; sheets, pillows and pillow-cases stained with black vomit; the pajamas which patients had worn at the time of their death. It was Dr. Reed's desire to have this material infected if it were possible to become infected in this way. Dr. John W. Ross, the superintendent of Las Animas Hospital, therefore gave the matter

his personal attention, saw to the packing of this material in chests for transportation to Camp Lazear, and before the chests were closed, had basins of black vomit and other excreta from yellow-fever patients poured over the contents of the chest. If there were any possibility of such material becoming infected, infection certainly would have followed such procedure.

Dr. Reed had this material opened up and spread out in the close room I have described. He called for volunteers to sleep in this room. Dr. R. P. Cook of the Army, and several soldiers quickly responded. These men put on the pajamas soiled as described, and slept on the mattresses and bed clothing soiled beyond description. For a period of twenty days they spent the nights in this building, but for the sake of general health were allowed to go out during the day. All the men remained perfectly well, and no case of yellow fever was developed from such exposure.

This set of experiments was generally accepted as proving that yellow fever was conveyed from man to man by the mosquito alone, and that it was not transmitted in any other way. A great many persons, however, were still skeptical. The experimental camp had been named "Lazear" in memory of Dr. Lazear, a member of the Board, who had died a few months before of yellow fever, contracted while prosecuting this work.

The Board then took the blood of a yellow-fever patient in the first three days of his sickness, and injected it with a hypodermic syringe into a non-immune. He promptly developed yellow fever. This proved that the blood of a patient suffering from this disease could transmit yellow fever without passing through the body of the mosquito. From this experiment of injecting the blood directly from one person into another it was argued that it might not be a yellow-fever parasite that was injected, but a toxin.

The Board then took the blood within the first three days of sickness from this second patient who had been given his disease from the blood of the first patient, and injected it into a third patient. This third patient developed the disease at the proper time. This experiment demonstrated that the virus so conveyed was capable of multiplying; that it was a living germ and not merely a toxin or chemical body which transmitted the disease.

The Board then took the blood of a patient collected in the first three days of his sickness, and passed it through a Pasteur filter so fine that it would stop any particle large enough to be seen with a microscope of the highest power. This blood when injected into a non-immune still gave yellow fever. This demonstrated that the parasite was sub-microscopic; that is, too small to

be seen by a microscope of even the highest power.

They then took the blood of a yellow-fever patient within the first three days of his disease, heated it to 55° C., and injected it into a non-immune. The non-immune did not develop yellow fever. This was repeated three times. This experiment proved that the living parasite in the blood of the yellow-fever patient was killed by being raised to a temperature of 55° C.

The conclusions announced by the Board were as follows:

That yellow fever is conveyed from man to man only by the bite of the female stegomyia mosquito, and that this mosquito, to become infected, must suck the blood of the yellow-fever patient within the first three days of his disease.

That after biting the patient, twelve to twenty days must elapse before she herself is able to convey the infection. This period is known as the period of extrinsic incubation. Extrinsic incubation in Havana was found to be considerably longer during the cool months of winter than during the warm period of summer.

That after the non-immune human being had been bitten by the infected stegomyia mosquito, an incubation period of from three to six days elapsed before the man began to show symptoms of yellow fever. The shortest period of incuba-

tion in Dr. Reed's cases was two hours less than three days, and the longest period, two hours more than six days.

That the blood, taken at the proper time and injected into a non-immune, would also cause yellow fever; that the disease was caused by a parasite, and that the parasite was sub-microscopic.

These discoveries have been of enormous benefit to mankind, and upon them has been based the sanitary work against yellow fever which has been so successful. At first blush, however, it was not evident to what extent it would be of practical use to us.

CHAPTER IV

THE SANITARY BOARD OF HAVANA

AT this time, February, 1901, I was health officer of the city of Havana. The efforts of the Department had been concentrated for more than two years previous upon controlling yellow fever in that city. Not only had we met with no success, but yellow fever was actually worse than when we commenced work. Ample funds and power had been given us by General Wood, the military governor, and we had by far the best and most efficient sanitary organization of whose existence, either before or since that time, I have any knowledge.

When the work of the Reed Board began to point to the mosquito as the conveyor of yellow fever, the Sanitary Department of Havana was at its wits' end and was glad to receive this discovery as a means of possible help. I, as health officer of Havana, had nothing to do with the work of the Reed Board in any way whatever, except that I was a very interested spectator and kept in

close touch with the work as it developed. We assisted the Board in every way that we could. All the hospitals in the city were under our control, so that we were enabled to furnish them ample clinical material.

Neither the Reed Board nor any of its members had anything to do with the practical working out of the methods whereby their theory was demonstrated, and by means of which yellow fever was finally eliminated from Havana. These methods were first originated and worked out by the Sanitary Department of Havana during the year 1901. They have since been copied and successfully applied in many parts of the world where yellow fever formerly prevailed.

Dr. Finlay, in a reprint from the *Journal of the American Medical Association,* April 19, 1902, says:

The final confirmation of the rôle which appertains to the culex mosquito deso (now included in the genus stegomyia of Theobald) in the transmission of yellow fever, has now been sanctioned by the experiments of Drs. Reed, Carroll, Agramonte and the lamented Dr. Lazear, at Quemados de Marianao, during the winter of 1900, and afterwards by those of Dr. Guiteras at the Experimental Station of Las Animas, last summer, and finally by the splendid practical results obtained by the Chief Sanitary Officer of Havana, Major W. C. Gorgas, during the epidemic year

which has just been completed. With those facts and the ones which I had gathered in former years, it is now possible to determine with some degree of precision the conditions which are necessary in order that yellow fever may develop in an epidemic form in a given locality, not too highly situated above the sea level and where temperatures between 25° and 35° C. (77° and 95° F.) either temporarily or habitually prevail.

Dr. Reed and I discussed on several occasions the possibility of making practical application of his discoveries. It did not seem to us possible to destroy the adult mosquito in sufficient numbers to be of any practical use. And we were not sufficiently familiar at that time with the life history of the mosquito to think of any other way in which the subject could be approached with a fair prospect of success.

We, of the Sanitary Department, after a great deal of discussion and thought given to the matter, decided that we should adopt all measures that seemed likely to be useful, being guided in our plans principally by the life history of the mosquito.

After the first two cases—in all some twenty-six—all the Board's cases had been very light. We concluded, therefore, that our strongest measure would be vaccination; that is, to have an infected mosquito bite a non-immune and give him a

light case. If this proved as successful as had vaccination in smallpox, we could see that this measure alone would entirely protect against yellow fever, just as had vaccination against smallpox. We consulted the military governor, General Wood, on the subject, and he agreed to let us try it as one of the several preventive measures which we were putting into effect against yellow fever.

We announced that we were ready at Las Animas Hospital to immunize against this disease anyone who wished to be treated in this way. There was no lack of applicants. This was in February, 1901. Most of the work of the Army Board had been done during the preceding fall, and at this time we had only one infected mosquito left, which had been given us by Dr. Reed. This old lady was a veteran in every sense. She had given several people yellow fever, but her greatest claim to celebrity was the fact that it had been fifty-seven days between the first case of fever and the last one which she had given.

The weather is cool in Havana during January, February and March, so that the stegomyia under ordinary conditions become quite sluggish in their movements and a great many die. Mosquitoes decrease so much during these months that yellow fever becomes more or less rare, and it was very difficult for us to infect our mosquitoes. While for one hundred and forty years there had never

been a single month in which there had not been some reported case of yellow fever in Havana, still only a very small proportion of these cases was recognized during the first three days, and it must be remembered that a mosquito has to bite within that period of the disease in man to become infected. We were, therefore, keeping our only infected mosquito with a great deal of care and tenderness, knowing that we had to depend upon her to start our vaccination work.

In all Havana there is probably not a single fireplace or other means of artificial heat, so we sent to the United States and imported an oil-stove wherewith to keep her ladyship's room always at summer temperature. Her home was a large glass jar on a table in the center of a sunshiny room. In this jar was hung a lump of white sugar on which she fed when hungry, and to this was added now and then a small piece of banana. A small vessel containing water was also kept in the jar. In order that she might have a plentiful supply of fresh air, the glass top was not placed upon the jar, but a sleeve of mosquito-netting was tied over its top.

Within the last fifteen years a great deal of study has been given to mosquito life. It is now known that there are some seven hundred different species of mosquitoes; that in all species of mosquitoes the natural food is the various vegetable

juices. In all species the female has to have a feed of blood before she can lay eggs. Blood does not seem to be necessary for life, but merely stimulates the function of ovulation. In order that the female may get this blood, she is furnished with biting apparatus not possessed by the male. The male never bites, not being physically able to do so. The female stegomyia, therefore, is alone concerned in the transmission of yellow fever.

Las Animas Hospital being the yellow-fever hospital for the city of Havana was a center of attraction for most of the doctors of the Health Department. Dr. John W. Ross, Dr. John Guiteras and myself were at this hospital almost every day. Dr. Guiteras had charge of the vaccination work and of the laboratory where the mosquitoes for this work were being bred. Our lady mosquito was therefore directly under his charge. She had given so many people yellow fever and was therefore so valuable for our prospective work that we all when at the hospital would drop in to see how she was coming along and to pay our respects.

One morning about daylight I got a message stating that her ladyship was in a most critical and desperate plight, as some time during the night she had gotten her wing caught in a mesh of the mosquito netting, and had struggled to free herself for so long a time that when she was discov-

ered by the attendant in the morning, she was almost dead. I rapidly dressed and hurried to the hospital. Similar messages had been sent to Dr. Ross and Dr. Guiteras. We found her condition even worse than had been represented. Two or three of the doctors on the staff of the hospital had been promptly called in, and the services of several of our trained nurses had been likewise obtained. Her wing had been gently liberated from the mesh of the netting, and her ladyship laid upon a soft bed of cotton batting. The oil-stove was started up, and the room brought to a very hot summer temperature, but it was all of no avail. She finally ceased to kick about nine o'clock in the morning, and died with a larger attendance of doctors and nurses around her table than had ever been present around the deathbed of any mere human in the city of Havana.

This account may sound somewhat exaggerated, but the scene still comes back to my mind's eye very vividly, how earnest and serious we all were. A half-dozen of the leading practitioners of Havana were sitting around the deathbed of this mosquito, looking and feeling exceedingly mournful and depressed. And it was a very heavy blow to the Health Department of Havana. It was well on into the summer, the month of July, before we succeeded in getting another infected mosquito, and in proceeding with our vaccination work.

Finally, we succeeded in infecting several mosquitoes, and bit with these mosquitoes sixteen persons, of whom eight developed the disease.

Much to our alarm, several of these cases developed very violent symptoms, much more so than had occurred in any of the cases of the Army Board, with the exception of Lazear and Carroll. Three of these eight positive cases vaccinated by Dr. Guiteras died; one of those who died was a Miss Maas, a trained nurse from the United States, who requested to be allowed to get immunity in this way. Why our cases should have been so severe, and all of the cases of the Board so mild, no one has attempted to explain. It is a fact that during the hot summer weather the extrinsic period of incubation in the mosquito, that is, the time after which the mosquito bites the man sick with yellow fever until she herself is able to convey the disease, is considerably shorter than the same period during the cool winter months, this period in the summer months being from twelve to fourteen days, and in the winter months, from fifteen to twenty days. I am inclined to think that there is probably the same difference in the virulence of the infection developed by the mosquito in the hot summer months, and in the cool winter months.

This experience demonstrated to us most forcibly that vaccination could not take any prom-

inent part in our preventive measures against yellow fever. While Dr. Guiteras was going on with his preparatory work at Las Animas and getting ready for his vaccinations, he invited to the hospital some fifteen or twenty members of the International Sanitary Congress who had expressed themselves as being particularly skeptical with regard to the mosquito theory of the transmission of yellow fever. This Congress assembled in Havana during the month of February, 1902. The laboratory at Las Animas was the room I have just described as being the home of the mosquito known as "Her Ladyship." It was carefully screened with wire netting at all the windows, and the single door was protected by a vestibule which itself had double doors. This vestibule was built upon a platform some four feet above the ground and just outside the door of the laboratory. The visitors pretty well filled the small room. Dr. Guiteras started at one end of his laboratory, explaining that in this jar he had the eggs of the stegomyia mosquito, and invited his visitors to examine them; in the next jar, the larvæ; in the next, the pupæ; in the next, the young mosquito just born, and in the last jar, the mosquitoes which had passed their period of extrinsic incubation and were now ready to convey yellow fever.

While handling this jar, the sleeve of mosquito-netting accidentally slipped off, and a dozen or

more mosquitoes soared toward the ceiling of the room. Our visitors stood for a moment dumfounded, open-mouthed and wide-eyed. Then each one of the twenty, at the same moment, made a rush for the door. The vestibule was small and would hold only about four persons, so that the pressure from behind toppled it over onto the ground four feet below, and in a moment, there were some twenty gentlemen in a pile on the ground struggling to get as far as possible from these deadly lady mosquitoes.

Dr. Guiteras afterwards assured us that his mosquitoes had never bitten a sick man and were not infected; that he was only demonstrating the processes of mosquito-breeding and infection that would have to be carried out in the vaccination process. Our visitors laughingly acknowledged that, at any rate, their subconscious selves had been convinced of the correctness of the theory of the mosquito transmission of yellow fever.

CHAPTER V

SANITARY WORK AT HAVANA

THE Army Board had demonstrated that the mosquito, to become infected, had always to bite some patient with yellow fever within the first three days of his disease. It was evident, therefore, that if we could prevent this being done in every case of yellow fever in Havana, the disease would disappear. This measure alone would be sufficient for eliminating yellow fever.

To accomplish this we required all cases of yellow fever in the city to be reported to the central office of the Health Department. They were at once seen by the official diagnosis commission, and if pronounced yellow fever, were at once moved to Las Animas Hospital in a carefully screened ambulance and placed in screened wards. The routine at Las Animas Hospital precluded the possibility of any mosquitoes biting the patient. Most of the Americans, and in fact patients of all classes, preferred to go to Las Animas. Under

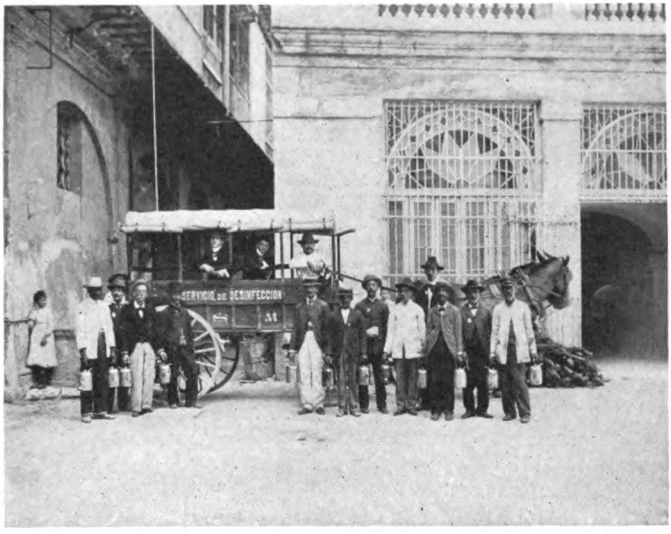
Dr. Ross's care the hospital soon obtained the reputation of saving more yellow-fever patients than could be done at the other hospitals, or at their homes. This reputation was justly acquired. The statistics of this hospital amply bore out the reputation which public opinion gave it. If the patient elected, he could stay in his own home, the room or rooms to be screened were agreed upon, a skilled force of carpenters were sent by the central sanitary office, who thoroughly and carefully screened the designated apartments. Only one point of exit and entrance was left, and this was protected by a vestibule and double door. A number of squads of carpenters, each furnished with its own wagon loaded with the necessary wire netting, lumber, and other material, were always on duty, so that usually within an hour after notice came to the central office night or day, the patient was either removed to the hospital or was being screened at his own home.

To see that sanitary regulations were carried out and that only authorized persons were admitted within the screened quarters of the patient, an officer of the Sanitary Department was always on duty. He sat in the vestibule and required that one door should be closed always before the second was opened. He was changed every eight hours, that is, he was on duty only eight hours in each twenty-four. We soon found that this

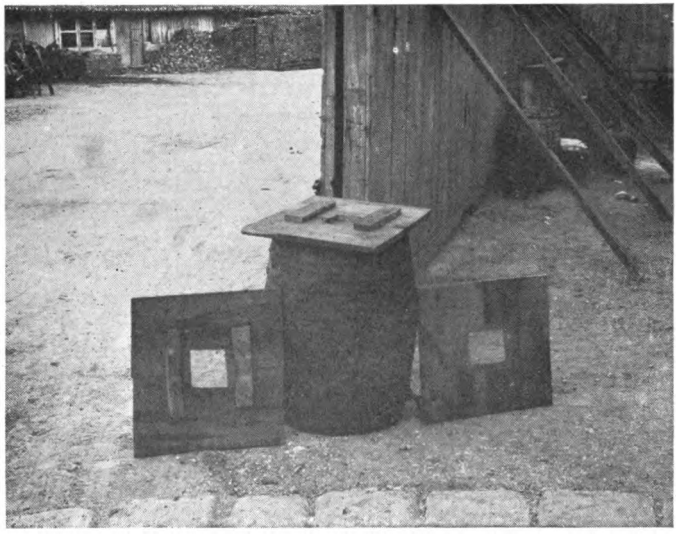
method could not be carried out in its entirety; that it was the exception that we could get hold of a patient during his initial chill. Generally the patient had been sick one or two days before he came under our observation.

It was evident, therefore, that a number of mosquitoes might have bitten him before he was discovered and cared for. As it would be twelve or fourteen days before these mosquitoes would become infectious, we had plenty of time to attend to them. From the known habits of the stegomyia mosquito we did not think they would leave the house in which they had become infected, though in an individual case this might occur, and a mosquito wander into a contiguous house.

To meet this condition of affairs, as soon as the case was concluded, the house in which the patient had been sick and all the contiguous houses were fumigated with such material as would kill the mosquitoes. In order that the fumigation might be effective the house had to be carefully gone over and all cracks and crevices stopped, so as to make the building as nearly air-tight as in the nature of things it could be made. This was a very laborious process and required care and expert supervision. Most of the stopping of crevices was done with paper and paste. Sulphur is probably the most effective substance in killing the mosquito. The rolled sulphur was used at



Stegomyia Squad. Havana.



Screened Water Barrel. Havana.

the rate of about a pound to the thousand cubic feet of space to be fumigated. We generally used the Dutch oven placed in a box of sand or vessel of water, so that in case of a leak, or in case of the oven's getting too hot, the floor would not catch on fire. With a large force of ignorant men engaged in this work constant watchfulness has to be used to see that fires do not occur. The proper amount of sulphur is placed in the Dutch oven, a little alcohol poured over the sulphur, and a match applied. The sulphur will burn for three or four hours, and will produce very dense fumes which will fill the building and kill all the mosquitoes. The fumes of sulphur in a building which has been well prepared will kill not only all mosquitoes, but all insect and animal life, and is by far the best material to use for this purpose. It is generally somewhat difficult to start the sulphur burning with alcohol alone, and I have noticed that the men got in the habit of using an ounce or two of pyrethrum placed on top of the sulphur for the purpose of starting the fire. The pyrethrum was moistened with the alcohol and would burn for a considerable time after the alcohol was consumed, in almost every instance starting the sulphur burning.

The fumes of sulphur will tarnish gilt metals of all kinds, and injure most light-colored fabrics. This occurs particularly where the air is heavily

charged with moisture. In cases in which sulphur was likely to do damage, we used pyrethrum powder. This powder does not tarnish or injure fabrics of any kind. The building must be prepared in the same way as for sulphur, and the vessel in which the pyrethrum is burned must be arranged as above described for sulphur. The fumes of pyrethrum do not generally kill the mosquito, but simply intoxicate her. In the course of time she revives and eventually entirely recovers. For this reason the building should be opened up within a couple of hours after the burning of the pyrethrum, and all mosquitoes carefully gathered and burned.

In almost all dwellings of the better class of tenants there are fixtures and fabrics which will be injured by the fumes of sulphur. Therefore, in this class of buildings we generally used pyrethrum. For fumigating in this same class of buildings where pyrethrum was used we found a mixture of camphor and carbolic acid, one part of camphor to three of carbolic acid, very useful. This should be placed in a tin dish and vaporized with a spirit lamp. The same procedure should be observed as a precaution against fire as is taken with sulphur. The mixture when vaporized gives off dense white fumes which kill the mosquito. Generally, where care has to be taken for fear of injuring fixtures and fabrics, this mixture is

preferable to pyrethrum. Pyrethrum should be used at the rate of one pound to the thousand cubic feet, and the camphor mixture at the rate of an ounce for the same space.

In Havana we had to deal with cigar manufactories and tobacco storehouses on a large scale. Here we could use neither sulphur, pyrethrum, nor the camphor mixture, as they all affected the delicate flavor of the tobacco. At first we used to move all tobacco out of a building to be fumigated. This was very laborious and added largely to the cost of fumigation and also tended to drive out from the building the infected mosquitoes before they had been reached by fumigation. Mr. Joseph Le Prince, who was in charge of this work, after much experimenting found that the fumes from tobacco stems did not hurt the flavor of tobacco, and were almost as deadly to the mosquito as was sulphur. We could therefore fumigate with this material buildings where tobacco was stored without injury to the tobacco. The stems were a waste product in cigar manufacturing, and could be obtained in large quantities at little cost. They should be used at the rate of two pounds to the thousand cubic feet, and with the same precautions against fire as are taken in other cases.

Formalin we found useless. It has apparently little effect upon insect life.

From our general knowledge of the life history

of all species of mosquitoes, we knew they had to spend eight or nine days in a larval stage, and that while in this larval stage they lived in water. Therefore, collections of water were necessary for the development of the mosquito. The stegomyia mosquito we knew preferred clear, clean water, such as is supplied by the various collections of rain water needed for domestic purposes. The city of Havana had pipe water over only a small portion of its area. By far the larger portion of the population obtained its water supply from rain water stored in cisterns, tanks and receptacles of all kinds. We resolved to stop mosquito-breeding in all such places.

The city was divided into twenty inspection districts, each district under the charge of a sanitary inspector. This inspector was required to get around to each house in his district once a month and make a careful inspection with regard to mosquito-breeding, and report to the central office on a printed blank the conditions found. If this report indicated that the condition of the premises amounted to a sanitary nuisance, the householder was proceeded against. An order had been promulgated making it a sanitary nuisance for any householder to have mosquito larvæ on his premises. The health officer was given authority to impose a fine for such nuisance; the fine was collected by the Cuban courts, and the proceeds of

the fine deposited in the Cuban treasury. The health officer had authority to remit the fine at any stage of the proceedings. In practice, it came about that the whole matter was settled in the Sanitary Department. We employed a lawyer to whom cases of fines were referred. When a householder was reported by the sanitary inspector as having larvæ on his premises, he was notified that under the sanitary ordinance he was fined five dollars for having this nuisance on his premises, but that if the nuisance were abated, the fine would be remitted. This usually brought the man promptly to the office with the statement that the nuisance had been abated. An inspector was sent around, and if the householder's statement was found to be correct, the fine was remitted.

In a certain number of cases this notice caused no action on the part of the householder. In these cases the fine was sent to the judge of the district for collection by him. In the few cases in which the first notice had not brought the householder to terms, this action by the court did. If he reported that he had abated the nuisance and the inspector when sent to investigate found this to be the case, the fine was withdrawn. In this way we did very little fining. Out of about twenty-five hundred fines levied in the last nine months of 1901, only fifty were finally imposed and deposited in the treasury.

The Sanitary Department was said to be decidedly the most popular of the American departments with the Cubans, and it was this very power of assessing and remitting fines that was the principal cause of our popularity. The Cuban had been accustomed to looking upon laws and ordinances as devices for filling the pockets of the officials, and fines as the legitimate perquisites of those officials. When a fine was remitted, he looked upon it as a personal present from the pocket of the chief sanitary officer to himself, and was grateful accordingly. Why the chief sanitary officer should take so great an interest in mosquito larvæ he could not comprehend. But that officer evidently did take a most decided interest in the matter, and had he not demonstrated his friendship by taking five dollars, which was as good as in his pocket, and giving it to him, the offender? His loyalty was appealed to and generally he remained ever afterwards the friend of the Department.

Cisterns, barrels and receptacles for containing and storing rain water for drinking and domestic purposes were absolutely necessary in the case of the larger part of the population. It was necessary that we prepare these receptacles so that they could not breed mosquitoes. If it were arranged so that mosquitoes could not lay their eggs on the surface of the water, this object would be

accomplished. It was therefore provided that all receptacles should be covered in such a manner that mosquitoes could not have access to them. The tops were covered, a small hole being left in the top by means of which water could enter. This hole was covered with wire netting, and a spigot was placed in the bottom whereby the water could be drawn off. This was done at public expense. At the central office squads of carpenters with material loaded in wagons were always on hand to go out for this work. If the sanitary inspector reported that such work was necessary, it was immediately attended to by one of these squads.

For carrying into execution the orders pertaining to mosquito work the city was divided into eight districts, each district in charge of a mosquito inspector. A great deal of stegomyia breeding went on in the interior of the dwellings. Every family had an earthen vessel in which drinking-water was kept for daily use. This always had larvæ in it. It was the inspector's duty to empty this vessel, point out the larvæ to the housekeeper, and explain that if the vessel were emptied once a day and the larvæ washed out, mosquito development could not occur. All sorts of vessels in a house which might contain water had to be considered as possible breeding-places for mosquitoes. Every housekeeper in Havana, when we started work there, had a number of breeding-

places for mosquitoes in her domestic establishment. Among these may be mentioned flower-pots in which a little too much water had been used; cans filled with water, in which the legs of tables had been placed as a protection against ants, etc.

Each mosquito inspector had with him five men, and one of these men carried a sufficient amount of oil to pour upon any pools or puddles about the premises that might need oiling. They picked up old bottles and cans which might contain water and become breeding-places, and generally looked after the yards. The district inspector, at the same time, made a general report on the premises in writing, and on this report the owner was called to account if unsanitary conditions were found existing.

Next to cisterns and water barrels, roof gutters were found to be the most general breeding-places for the stegomyia mosquitoes. Leaves and trash fall upon the roofs, are washed into the gutters, and these make little dams behind which water collects and remains after the rain has ceased. At other times the gutter sags and thus forms a collection of water. In the tropics you can always count upon roof gutters as being places for mosquito-breeding, and being inaccessible and difficult to inspect, such breeding-places are seldom disturbed.

During its larval stage the mosquito lives entirely in water, but has to come to the surface frequently for the purpose of getting air. This necessity is seized upon by man for the purpose of destroying the larvæ. If kerosene oil is poured upon the water, it spreads in a very thin film over the surface. Now when the larvæ rise to breathe, the oil gets into their breathing-tubes when they attempt to force them through the thin film of oil spread over the surface of the water. This suffocates and kills the insect and is very effective.

It is very surprising and impressive to see how rapidly such a system will free a city of mosquitoes, and how after a few months of such work you cease to be annoyed by them. In yellow-fever work this system of destroying mosquito larvæ is the essential; everything else is secondary to it. In the built-up portions of a city such as Havana, caring for the cisterns, water barrels and containers is the essential work, but as you approach the suburbs, pools and puddles become more frequent, and this character of mosquito breeding-places becomes more important than containers. Wherever possible these breeding-places should be drained, though oiling in this class of work has a very useful field. In the suburbs, in these pools and puddles, the anopheles, the malarial mosquito, becomes common and this disease has to be looked after. We had fifty men

engaged in this work, under a different set of inspectors from those doing the stegomyia work. This was made necessary, as the men doing the anopheles work were occupied almost entirely in the suburbs of the city. The details I will describe in another place.

CHAPTER VI

THE RESULTS ACCOMPLISHED IN HAVANA

FROM the account already given of yellow fever it is evident that the parasite has to be introduced into a locality, either in the body of a human being sick of yellow fever, or in the body of a female stegomyia mosquito which has become infected by the parasite. It is evident that if the health authorities can keep out these two sources of infection, yellow fever can never occur in that locality.

With this object in view we established a modern quarantine at Havana. Any ship coming in with yellow fever aboard was placed in quarantine. The vessel itself was fumigated so as to kill all the mosquitoes. This rendered the ship safe. All the non-immune crew were taken off, carried to quarantine station, where they were cared for during a period of six days. If no sickness developed during this period, it was concluded that the infected mosquitoes aboard the ship had not

bitten these non-immunes up to the time of their departure. They were therefore released and allowed to return. The immunes were not considered liable to yellow fever, even if they had been bitten by the infected mosquitoes.

One attack of yellow fever gives such great protection that, in practice, a man who can prove that he has once had the disease is looked upon as entirely safe. But of course he has to prove this to the satisfaction of the quarantine physician. It is considered so certain that everyone exposed to yellow fever will have the disease that proof that a man has lived in an endemic center for ten years is accepted as proof of his immunity. No quarantine is, however, absolute in any disease, in any locality, or carried out by any authority. Some people now and then will pass the quarantine who are either so slightly sick that the disease is not recognized, or who developed the disease after they had been released from quarantine. But a quarantine greatly lessens the number of times and the frequency with which infection is introduced into a locality.

For some reason yellow fever, in the minds of people generally, is covered with a cloak of mystery. In communities where it prevails there are hundreds of remedies and courses of treatment that are vaunted as being infallible cures, and the more ignorant and uneducated the possessors of

these specifics, the more readily they seem to be accepted by the people generally. But yellow fever, like every other acute disease, has its own natural history, and man at present knows no remedy that can shorten or change its course. Many a time I have found myself completely routed in cases of yellow fever by the old negro mammy, who would insist that if the patient would take orange-leaf tea and adopt certain other procedures which she advocated, the patient would certainly get well. Now, on the average with severe yellow fever, seventy-five per cent. will recover and twenty-five per cent. will die. The negro mammy did not know this, but was firmly convinced that it was the orange-leaf tea which caused the recovery in the cases of those who recovered, and some departure from her directions that caused death in the case of those who died. She believed that if her routine had been carried out in the fatal cases, they would have recovered. I must confess, however, that in my experience the measures generally advocated by the negro mammy did little or no harm, and in looking back over a yellow-fever experience of thirty years, I cannot by any means make so strong a statement with regard to my professional brethren.

One of the most general superstitions with regard to yellow fever was that all air must be kept

from the patient. With this in view, the room in which the patient was treated was kept closed and entirely dark. No water for washing the face and hands, no change of body or bed clothing was allowed during the course of the disease. The conditions, therefore, as to filth when a patient had been ill five or six days can be better imagined than described.

I was once called into consultation by a medical friend of very high standing in one of the best and most aristocratic Havanese families. The patient was a young American teacher who had been brought to Havana a few months before in connection with the education of a large family of children. She had been sick with yellow fever some five or six days when I saw her, and I recognized without much examination that she was fatally ill and had but a few hours to live. Her Cuban friends were devoted to her, and were willing to do anything for her comfort and recovery that their wealth could command. As is generally the case in yellow fever, her mental faculties were perfectly clear, and her physical strength good, although she died within six hours after I saw her. She was delighted to see me, and begged me earnestly to induce her friends to let her bathe her face and hands and have clean clothing; for neither of these luxuries had been granted her since she was taken sick. I urged my medical

friend who had called me into the case to allow the poor girl to have these things, and I knew that he agreed with me that they could do no possible harm. He said that he would try, but that probably the only result would be that he would lose the confidence of the family and do the poor girl no good. We both urged this upon the family, but so strong was their belief that such a measure would deprive their friend of such little chance of recovery as was left that they would not consent.

In times of stress and danger such as come about as the result of an epidemic of yellow fever, many tragic and cruel phases of human nature are brought out, as well as many brave and unselfish ones. Some tragedies stand out prominently in my recollection.

When yellow fever was at its height in Havana, our chief commissary, an officer of the regular Army, was taken sick and his disease was soon recognized as being yellow fever. His wife had left Havana a few weeks before to make a short visit to her home in Cincinnati. I had promised that if my friend should get yellow fever, I would cable his wife. I did so, and the wife received the cable while at a dinner-party. She started for Havana at once and reached Las Animas Hospital a day or two before the Major, her husband, died. The tie between husband and wife was un-

usually strong, and as she was assured that hope was departing, her grief was very great. This was before we knew that the mosquito alone could convey the disease, and when we had some general idea that it was infectious, and in some way contracted by contact with fomites, and with those who were sick of the disease.

The wife as she saw death approaching determined, if possible, herself to contract the dread disease. I heard her appeal to her husband in most moving terms not to die and leave her alone. She was with her husband at the moment of his death, and held him in her arms at the time. One who is familiar with a deathbed scene from yellow fever can appreciate what this means. It is a very gruesome death, and the young wife was covered with "vomito negro."

I felt myself more or less responsible, and thought that she was going into the jaws of death by this kind of exposure. I therefore called for the assistance of one of the nurses, and used some force in getting her into the next room. She at first reproached me, but as soon as we got her into the adjoining room she seemed at once to regain her mental balance, spoke rationally to Mrs. Gorgas, and asked me to arrange the details so that she could take her husband's body with her when she sailed on the next vessel for the United States.

Mrs. Gorgas and I walked with her to her room and gave certain directions with regard to her care and comfort for the night. She asked me for a sleeping dose which she might take in case she was unable to sleep. I recollect that I put this up in such quantity that she could not hurt herself even if she took it all. The rooms were separated by very thin wooden partitions, and she asked about the location of persons in the adjoining rooms.

About two A. M. Mrs. Gorgas and I went to our quarters. We had been home just a short time when I was aroused by a hurried step and a knock at the door. I found it was a messenger summoning me to the hospital, with the information that the lady had killed herself.

When the door of her room was forced, we entered and found our friend apparently in a peaceful, quiet sleep. One arm had dropped naturally to the side, and the right arm was lying across the chest, the hand still holding the pistol with which she had killed herself. The appearance was exactly that of a piece of marble. She had shot herself behind the ear, and the hemorrhage had been so sharp that the body was entirely blanched. From where we stood the hemorrhage did not show. She had concealed a pistol in her trunk which she had procured in the United States at the time she started for Havana. She

had placed fresh clothing on a chair by the bedside, apparently with the intention of being robed in it after death.

In looking back I could see various things in her actions and conversation that indicated the intention of taking her life. At other times she had entirely forgotten this, and was preparing for her sad future in this life. She had apparently been dazed by her grief and was temporarily unbalanced, unable for any length of time to follow in her mind any definite plan of action.

The Major having been our chief commissary and a man with whom we were in daily contact, this tragedy profoundly affected the military community. The next day we took husband and wife out to the little military cemetery at Camp Columbia where the American troops were cantoned, some five miles from Havana, and laid them to rest in the presence of a large concourse, military and civil.

While there, a member of the Commanding General's staff, Captain Page, had a chill, returned home sick, developed a severe case of yellow fever and died within a week. This was looked upon by all the community as evidence that the disease had been contracted by contagion from the Captain's having attended the funeral.

From the table on page 71 it will be seen that for ten years preceding our occupation of Havana

DEATHS FROM YELLOW FEVER IN THE CITY OF HAVANA

YEARS	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878
MONTHS																							
January	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18	20	32	7	16	24	8	26
February	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	23	13	23	4	16	24	9	13
March	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12	4	27	18	32	29	11	5
April	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	54	4	37	22	34	33	8	28
May	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	91	13	127	85	32	103	16	53
June	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	201	68	378	172	142	292	143	184
July	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	234	68	416	361	187	675	249	504
August	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	138	70	127	416	144	250	285	374
September	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	72	59	35	186	102	97	234	179
October	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	55	38	28	91	109	42	185	106
November	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	51	85	5	42	105	31	150	53
December	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	42	73	9	21	82	19	76	34
TOTAL	1309	2058	1396	1193	439	1020	1386	550	555	238	51	591	290	1000	572	991	515	1244	1425	1001	1619	1374	1559

YEARS	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901
MONTHS																							
January	11	16	7	9	14	26	4	4	5	8	17	10	10	15	15	7	15	10	69	7	1	8	7
February	13	9	3	11	9	16	3	0	6	8	5	4	3	10	6	4	4	7	24	1	0	9	5
March	6	20	3	14	21	8	1	0	8	14	5	4	4	1	4	2	2	3	30	2	1	4	1
April	13	44	6	18	34	32	2	1	22	24	8	13	5	8	8	4	6	14	71	1	2	0	0
May	40	40	6	84	75	55	3	1	84	26	17	23	7	7	23	16	10	27	88	4	0	2	0
June	237	50	37	176	162	66	4	14	128	36	37	38	41	13	69	31	16	46	174	3	1	8	0
July	475	179	90	195	177	131	13	33	102	74	48	67	66	27	118	77	88	116	168	16	2	30	1
August	417	48	127	73	148	97	34	39	73	113	73	60	66	67	100	73	120	262	102	16	13	49	2
September	148	75	94	56	50	41	32	37	36	63	37	33	65	70	68	76	135	166	56	34	18	52	2
October	44	32	39	33	72	24	41	16	33	48	21	32	48	54	46	40	102	240	42	26	25	74	0
November	31	21	38	36	45	8	22	13	20	33	21	15	24	52	28	23	35	244	26	13	18	54	0
December	9	11	35	24	42	7	6	9	15	21	14	9	17	33	11	29	20	147	8	13	22	20	0
TOTAL	1444	645	485	729	849	511	165	167	532	468	303	308	356	357	496	382	553	1282	858	136	103	310	18

there had been an average of more than five hundred deaths per year from this disease in the city; that in 1900, two years after we had taken possession of the city there were 310 deaths from yellow fever. A further search of the mortality statistics shows that yellow fever had existed in Havana continuously from the year 1762. This was the year during which Havana was besieged and captured by the English forces. The troops were largely made up of colonials from the North American colonies, and they suffered severely from yellow fever. For two hundred years before this time Havana had been subject to epidemics of yellow fever, but from 1762 up to the year 1901, there was probably not a single day when Havana did not have a case of this disease within its bounds.

In February, 1901, the measures above described were begun. Under these measures yellow fever rapidly disappeared, and in September of that year, the last case of yellow fever occurred. With one exception there has been no case of this disease in Havana since that date.

The work directed against mosquitoes had an equally good effect upon malaria. While the work done with the view of getting rid of the stegomyia was effective to a certain extent against the anopheles, the principal anti-anopheles work was executed in the suburbs of the city. It is a gen-

eral rule that malaria does not occur in the heart of a city, but generally in its outlying districts. The reasons for this will become evident when I describe anti-malarial work in one of our future chapters.

DEATHS FROM MALARIA IN THE CITY OF HAVANA

Year	No.	Year	No.	Year	No.	Year	No.
1871	262	1882	223	1893	246	1904	44
1872	316	1883	183	1894	201	1905	32
1873	329	1884	196	1895	206	1906	26
1874	288	1885	101	1986	450	1907	23
1875	284	1886	135	1897	811	1908	19
1876	334	1887	269	1898	1907	1909	6
1877	422	1888	208	1899	909	1910	15
1878	453	1889	228	1900	325	1911	12
1879	343	1890	256	1901	151	1912	4
1880	384	1891	292	1902	77		
1881	251	1892	286	1903	51		

It will be seen from this table that before the year 1901 Havana had yearly from 300 to 500 deaths from malaria, rising as high in 1898 as 1,900 deaths. Since 1901 there has been a steady decrease in the malarial death rate until the last year of the table, 1912, when there were only four deaths. Four deaths from malaria in a city of the size of Havana, about 300,000 population, means the extinction of malaria in that city. For the island of Cuba is in the tropics, and there are many malarious localities through the country districts. Havana is the metropolis of Cuba, and has in its environs the largest and best equipped hos-

pitals of the country, as well as the most distinguished surgeons and physicians. The sick, therefore, are brought from the country in considerable numbers, and a great many cases of malaria are brought in among these outside sick. The tables quoted above include all persons who died within the limits of the city of Havana, whether they came from the outside, or were residents of the city; whether they died in the large hospitals of the city, or in private houses.

Four deaths in one year from malaria can very safely be put down as coming from the outside, and it can with equal safety be said that by 1912, malaria had become as completely extinguished in Havana, as had yellow fever in 1902.

The extinction of malaria, however, did not attract anything like the attention that the extinction of yellow fever had aroused. The work of Dr. Ronald Ross and his co-workers with the anopheles mosquito, and of Reed and his associates with the stegomyia, undoubtedly gave the knowledge whereby the practical extinction of malaria and yellow fever was accomplished at Havana, but the accomplishment of this work with regard to yellow fever was the event which attracted the greatest attention. It seems almost providential that we had all the machinery at hand whereby the discoveries of the Reed Board could be immediately tested and demonstrated. Here

was a large city of 250,000 inhabitants in which yellow fever had been endemic for one hundred and fifty years. The American Army had been in control of the city for two years, and the Health Department was thoroughly organized and equipped and under the charge of a medical officer of the regular Army. Dr. Reed himself was strongly impressed with the advantage it had been to him to have his discoveries given so thorough and conspicuous a test, and wrote me to that effect many times.

There has been a great deal of discussion as to who deserves the credit for this great discovery. Undoubtedly Reed and his Board brought all the threads together and actually made the great discovery, but Finlay, Sternberg, Carter and others, started the spinning of many of these threads. Like all great discoveries everywhere it was gradually led up to by many workers.

Nothing is more true than the following quotation from one of Huber's papers:

And let me premise here, that in science at least, great names are landmarks; and the owners of these names have traversed and gleaned in fields where many a devoted laborer had delved and sown, and pathetically sweated blood in his altruistic zeal. In science at least no man works in vain. Full many an one, worthy of an elegy, has given his whole life to establishing a fact, or in-

deed only an item to a fact; his work unrealized, ridicule and even persecution ofttimes his only compensation, throughout perhaps in the meanest destitution, yet his life and his work have been absolutely essential to the building of a mighty fabric. Martyrs have been many among such—dying from the diseases from which they sought to defend others; knowing, too, full well, what their own fate would be. Nor does it in any wise detract from the gratitude due the great man that he has profited by the labors of others, adding what he can of his own, scrutinizing every detail, every datum, permeating and illuminating with his own genius, cementing the mass with his own deductions.

And from Flexner:

Remarkable achievements are never unique occurrences in nature. Even the greatest men rest on the shoulders of a multitude of smaller ones who have preceded them; and epochal discoveries emerge out of a period of intellectual restlessness that affects many minds.

CHAPTER VII

CORRESPONDENCE WITH DR. REED

AS illustrating the way in which we looked at conditions at Havana at the time that our mosquito work was first begun, I will quote correspondence which took place between Dr. Reed and myself at this time.

(1)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, May 16, 1901.

MY DEAR GORGAS:

Briefly speaking, how is the yellow-fever situation in Havana? I got your report for April and noted, with much pleasure and satisfaction, your enthusiasm in tackling C. fasciatus and her numerous cousins. Later, I think on May 4th, I read of "a serious outbreak" in your town, to the extent of two cases. Since then I have heard nothing concerning the progress of your epidemic. How many cases have you at the present writing, and what

are your prospects of prognostications for the future? I ask for this information particularly because Dr. Durham, of the English Commission, in a letter recently received, has proposed to join us in Cuba for the purpose of trying to reconcile his work, or rather the results of his work, at Para, Brazil, with our observations at Quemados, and as he will reach here during the last week in May, it is barely within the bounds of possibility that you may again see us back in our old haunts by July 1st. Everything will depend upon Dr. Sternberg's decision. . . . As much as I should like to see you and other friends, I would prefer to spend the summer in the United States. I hear that my friend, Kean, has been promoted to be the head of Charities and Correction for the Island. Who, then, is Post Surgeon at Columbia Barracks? How does Dr. Guiteras succeed at his propagating station? I trust that your own and Mrs. Gorgas' health is very good. Please remember me very kindly to the latter and to Col. Havard and Glennan.

Sincerely yours,
WALTER REED.

(2)

Havana, Cuba, May 22, 1901.

MY DEAR REED:

Yours of the 16th received. I wrote you a day or two ago, but I have forgotten whether or not I answered your question.

The fever situation is all that could be desired, I think. The last death from yellow fever oc-

curred on March 13th. Since that time we have had a case April 21st; another on April 22d. We had no more cases then till May 6th, when we had one; and on May 7th, three more. Since that time, two weeks, we have had no more; and as the conditions, as far as non-immunes are concerned, seem more favorable for the spread of yellow fever, I am in high fettle.

I am inclined to attribute our freedom to the way in which we killed the mosquitoes. We have fifty men at this work, oiling and draining small collections of water in every house and putting oil in all the sinks and closets so that it will run down into the cesspools. During the winter and cool periods of the year, up to this time say, the cesspools are the great places for breeding mosquitoes. All the cesspools, so far, have larvæ in them; when water barrels and cisterns in same yard have none. I am inclined to think that Dr. Guiteras, and other mosquito breeders, would get much more vigorous larvæ if they would use blood or some richer food than mere bread. We have been trying them side by side and find that sewer water develops much more hardy and large larvæ than rain water with bread alone in it.

I have had all the little streams and ditches in the suburbs cleaned and oiled; and we have killed a great number of larvæ.

You can go to any sewer mouth now and see the dead larvæ running out in considerable numbers, coming principally, I think, from the fosomauros, where they have been killed by the oil which would no doubt remain upon them for several hours.

But we have evidently had some tough old infected fellows, who have hibernated through the winter. For instance, on the two cases that occurred on the 21st and 22d of April (in different parts of the city, however), the mosquitoes were killed as thoroughly as we knew how. Every room in the house was closed; and a pound of pyrethrum powder burned to 1,000 cubic feet, and oil used everywhere, sewers and everywhere else. Not only was this done in the infected house, but in the fifteen or twenty contiguous houses. On each case we used 50 pounds of pyrethrum powder and something like 40 gallons of oil. I think the results show that we probably got hold of the infected mosquito or mosquitoes. We did the same thing on May 6th and 7th; and it now looks as though we had gotten hold of the infected mosquito there.

The prospect of getting infected mosquitoes now is poor. So far we know of none in Las Animas; all the cases this year having been exceedingly mild. It takes a Board with decided "amarylic" to diagnose them.

Would like very much to see you, Durham and Carroll down this summer, that is if you did not object to coming.

Dr. Gaylor, of the New York Pathological Laboratory, wants to take a whack at yellow fever, after his success at cancer. He asked me to let him know when I could get him some more autopsies of yellow fever, and he would come down at once.

We have things nicely fixed at Las Animas now; and I think we would do good work if we only

had yellow fever; but of course we can do nothing if we don't have.

Mrs. Gorgas has just returned from the "States" and joins me in kindest regards. I got weak in the knees and was afraid to keep our small girl down here, even though we had no infected mosquitoes.

Very truly yours,
W. C. GORGAS.

(3)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, May 23, 1901.

MY DEAR GORGAS:

I had only just penned you a short note, inquiring into the yellow-fever situation, when here comes your most welcome and interesting letter of May 15th. I was so much interested in Guiteras' results. One positive case in nine inoculations is better than we had at first. We only succeeded with our *tenth* individual. Of course, you were biting often with non-contaminated mosquitoes, as your fever cases were doubtful. Cases 3 and 6 should have failed. I expect better results from your May-infected mosquitoes. I see that Finlay and Guiteras continue to harp on the harmlessness of a *single* mosquito's bite, drawing the conclusion that ordinarily y. f. is due to *multiple* bites. After some poor devil dies, they may change their minds. Carroll's severe illness was due to a *single* insect and poor Lazear died from a *single* bite. Why are not malarial fevers gener-

ally double or multiple infections? We know that the opposite—single infections, as shown by one group of parasites—is the rule. . . . What's the need for us to return, if you have no y. f.? Havana should get a more accommodating Chief Sanitary Officer! Hurry up your new infections.

Again thanking you for your letter and the copy of G.'s report, and with best regards to your wife, believe me,

Sincerely yours,
W. REED.

(4)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, June 5, 1901.

MY DEAR GORGAS:

Your very kind letters of May 22d and 23d have both been received. Please say to Dr. Finlay that I will send a copy of our last paper just as soon as we can get it from "American Medicine." It hasn't been published yet. I hope to have it soon. You shall certainly have a Reprint. What you tell me about the y.-f. situation is certainly very encouraging, *but* were not the *results* just as encouraging in *1899*, at the same season? I will admit that you must have more non-immunes in Havana now than in 1899. Of course, you understand, my dear Doctor, that the control of yellow fever during this epidemic season, is to me the all-absorbing and important question, and it is on this very account that I am afraid that you and I might be led, in our enthusiasm, to think that more should be attributed to the sanitary measures now

being carried out, than to the season, or some other conditions of which we might be ignorant. It is simply a delight to read that you are "in high fettle," and I consider the city fortunate in having a Health Officer who believes that he can master the problem. I am astonished at the strength of your mosquito-destroying sanitary squad. What you say about the cesspools as breeding-places is intensely interesting. We got our first good supply of larvæ from an old can containing some feces at Columbia Barracks, and since then we have added a little fecal material to our breeding jars and have found that larvæ thus fed grew much more vigorously than those in ordinary water. Your experiments agree fully with ours. You are certainly doing effective work toward their destruction. I was astonished at the amount of pyrethrum that you are burning to the 1,000 cubic feet. Is such a large amount necessary, do you think? Won't you soon exhaust the supply? At Mount Vernon B'ks, where culex was very abundant, I used to find that about 2 or 3 ounces would intoxicate every mosquito in a room of some 3,500 cubic feet, so that I could sweep them up and burn them before they "sobered up." Certainly your plan of destroying insects in the surrounding houses is worthy of all commendation. However, be sure that your sanitary measures do not prove obnoxious to the Cuban doctors and laymen, or otherwise they will certainly conceal their milder cases. While the destruction of the mosquitoes is very desirable, I consider the thorough protection of the patient against their bites as of even greater importance. I cannot believe that

in so large a city . . . that you can possibly accomplish this. The undertaking, to me, seems well-nigh impossible. They *will* conceal their cases, *do what you may;* and these cases will be the foci for other cases. I can see no other alternative for this summer, at least. Still, you will undoubtedly be able to control the spread of the disease better than ever. . . . Pardon this long letter. Good luck attend your well-conceived regulations. Health and happiness attend you and yours.

Sincerely, your friend,

REED.

Dr. Reed here considers a squad of fifty men doing sanitary work in a city of two hundred thousand inhabitants at large. Four years afterwards, in the city of Panama, a place of twenty thousand inhabitants, we had six hundred men doing the same work. Major Reed is inclined to think fifty pounds of pyrethrum to a case a large amount. In 1905 in Panama we used two hundred and forty thousand pounds during the year. I call attention to this as showing how little any of us appreciated the magnitude of the job when we first started in.

(5)

Havana, Cuba, June 13, 1901.

MY DEAR REED:

Yours of June 5th received. I inclose you a copy of Dr. Guiteras' report for May.

We see still no success from our inoculations in twenty-two cases, but the great "but" comes in. I am not sure that any of the cases bitten were yellow fever. One of the last, from Tampico, I thought a pretty well marked case, though not dangerously ill, but his mosquitoes, on the 20th day, did not infect. I am disappointed beyond measure. I had hoped by this time to have Las Animas full to overflowing with inoculated cases, and be turning out immunes at the rate of some two hundred a month. But may be it is well as it is; in our enthusiasm we might have infected the city.

No case of yellow fever since May 7th, and still none on hand. The Board diagnosed one early in the month, but it turned out a well-marked case of typhoid fever. Of course I agree with you that nothing very definite can be deduced from our results this early in the season, though personally I am very much impressed by them. Our condition now is very much better than it was even in '99, with regard to yellow fever, and of course our liability to it is very much better. '98 and '99, with regard to yellow fever, should be left out, as in these years there were no non-immunes in Havana, and they would not have had yellow fever no matter what the condition of infection would have been. I except of course, the latter part of '99.

From the 1st of March to the 16th of June in '99 (and mind you this has been far and away the best record Havana ever made), we had four deaths from yellow fever. In the same period this year, we have had one, which occurred March

16th. The deaths in '99 occurred scattered over this period. It seems to me that the present condition of affairs indicates that we have been doing something that has had a great effect upon infection; and of course the only thing we have done this year that we did not do last year is the destruction of the mosquito. We commenced this work about the middle of February, just about the time that yellow fever practically disappears.

On the 12th of June, 1899, we had had for the month two cases of yellow fever, and in 1900, six. If you consider the amount of work there was to be done, to put oil in all the cesspools, all the water barrels and all the cisterns, once a month, and then keep the streams and pools in the suburbs drained, you will understand that seventy-five men is not at all a large force. I think I could use to advantage more. As you say, we could use less pyrethrum. We arrived at the rate of a pound per 1,000 cubic feet by experiments at Las Animas. We found that in this ratio we could kill mosquitoes in one and a half hours. It would probably be just as well to intoxicate them and sweep them up, and I shall probably cut down the quantity in a short time. We have to sweep them up anyway. But feeling that it may be possible that we have no infected mosquitoes in Havana I want to do everything I can think of, when a case occurs, to increase the chances of killing the infected mosquito in the neighborhood of where the patient got his infection.

We are using now from one hundred to two hundred pounds to the patient, killing the mosquitoes everywhere within half a dozen houses of

the patient's home. There is less objection raised to this than to the ordinary disinfection. It damages nothing, only keeps them out of their room for an hour or two, and kills the mosquitoes. I think there is much less opposition to us on this account than there was last year.

I feel confident that there is very little concealment of cases, and I do not feel much anxiety on this score. We cannot have many light cases without having a death now and then, and deaths would almost certainly be reported.

But what gives me the greatest confidence is that our non-immunes are made up entirely of Spaniards and Americans. The Americans promptly report themselves where there is anything suspicious, for the sake of the better care that they get at Las Animas. The Spaniards are all matriculated at one of the three "quintas," and go there as soon as they are sick from any cause. These "quintas" are all very anxious to try and catch up to the record of Las Animas, and report every case that they think, by any possibility, will pass the Board. And then, too, I can control the "quintas" by frequent inspections. So it seems to me that there is very little probability of cases being concealed to any extent. Still, we can speak more definitely on this subject about the 1st of December than we can now.

All well. With kindest regards, I remain,

Very sincerely yours,

W. C. Gorgas,
Maj. & Surg., U. S. A.
Chief Sanitary Officer.

To Maj. Walter Reed,
Washington, D. C.

(6)

Army Med. Museum, June 27, 1901.

MY DEAR GORGAS:

I thank you so much for your last kind and most interesting letter of June 13th. Really, my dear Dr., in spite of a few disagreeable things and people, when I think of the absence of yellow fever from Havana for a period of fifty days, I begin to feel like rejoicing that I ever was born! You are doing a splendid work for your corps and profession in Havana.

. . . . . .

Sincerely, your friend,

REED.

(7)

Army Med. Museum, Washington, July 29.

MY DEAR GORGAS:

I was on the eve of writing to you, when your kind favor of the 20th inst. reached me. The news from Havana is simply delightful. I am willing to confess that my fears that physicians would fail to report cases of yellow fever to your office, and thus maintain foci of infection, were groundless. It shows that your acquaintance with the local conditions were much better than mine. That you have succeeded in throttling the epidemic appears to be beyond question, and is to your everlasting credit as an energetic Health Officer, who saw his opportunity and grasped it. A man of less discretion, enthusiasm and energy would have made

a fiasco of it. Whereas, you, my dear Gorgas, availing yourself of the results of the work at Camp Lazear, have rid that pest hole, Havana, of her yellow plague! All honor to you my dear boy! Thank God that the *Medical Department* of the U. S. Army, which got such "a black eye" during the Spanish-American war, has during the past year accomplished work that will always remain to its eternal credit! I had seen in the papers report of the cases at Santiago de las Vegas. I am delighted that you have taken charge of the suppression of this outbreak. Of course, you will soon stamp it out, if you can enforce your regulations. I shall look forward with the greatest interest to your work there. *Please keep me posted.* I did not get your June Report, which I should like to have very much. Apropos of the outbreak at Santiago de las Vegas, I have concluded to have Carroll go to Havana, for the purpose, if he can get hold of any cases of yellow fever, of making a few observations on human beings, which will be a valuable guide to us at the present stage of our search for the parasite. I sincerely hope that he can succeed in getting hold of a few recently arrived immigrants for this purpose. I especially ask your kind assistance in this matter. I see that Gen. Wood has left Havana so that I am afraid that Carroll cannot get any money with which to pay the subjects of experimentation. Have you any funds with which they could be paid $1.00 per day? I think that you said that subjects could be obtained at that price. Carroll would like to do his work at Las Animas Hospital. Can that be arranged? He must start on

his return by Sept. 20th, if possible. So that he has but little time in which to accomplish the task before. Still if he can draw blood from a few undoubted cases and can get a few subjects, it won't take him long to decide the point. I wanted to come very much, but I have work here which I feel that I should not neglect. Else I should have certainly come down. I have been intending to ask you whether, in dealing with y. f. in Havana, this year, you have confined your work to simply protecting the sick against bites and destruction of mosquitoes; and have *omitted* all disinfection of bedding and clothing. I sincerely hope that this is true. I shall probably present, with Carroll, a paper to the next meeting of the American Public Health Association on the management and prevention of yellow fever, and I would so like to be able to say that the great work in Havana was accomplished without the disinfection of any bedding or clothing. Carroll leaves New York, with Pvt. Springer, on Ward Line leaving on Wednesday, August 6th. Pardon this lengthy letter. Please present my kindest regards to Mrs. Gorgas. Keep me informed of your progress at S. de las Vegas.

Sincerely yours,

REED.

The parasite has not yet been discovered. Dr. Carroll proved by the experiments which Dr. Reed here refers to that the parasite of yellow fever is sub-microscopic.

(8)

Havana, Cuba, August 26, 1901.

MY DEAR REED:

Yours of July 29th received. You will see by the last report that our conditions continue good. So far this month we have had only two cases belonging to Havana, one of these a Cuban child twelve years old who had never been out of Havana. Personally, I have not seen a case since March, belonging to Havana, with which I was perfectly satisfied as being yellow fever, but I am more confirmed in my suspicions since we have had the Santiago de las Vegas cases.

You recollect we bit some thirty-four subjects at the time when I last wrote you without being able to transmit the disease in a single instance. These mosquitoes we tried to infect on some dozen of these supposed Havana cases.

We all agreed that the Santiago de las Vegas cases were yellow fever. While they were not severe, they were well-marked cases of yellow fever. We bit one man with eleven mosquitoes. He was a well-marked case, but not dangerously ill at any time. These eleven mosquitoes have since bitten seven subjects, six of whom have gone down with yellow fever. Three have recovered and three died. Carroll will no doubt give you details in these cases, and Guiteras will publish the matter in detail.

I am very much disappointed. I had hope that through the mosquito we had a means of giving mild cases which would protect, but these cases

show that the severest form of yellow fever can be transmitted by one or two mosquito bites.

I suppose I ought to be thankful for the immense good that the discovery so far has done, and for the great success that our work this year has had, but the death of these patients, just now, makes all success taste of gall and wormwood, and casts a gloom over the Sanitary Department.

From a practical standpoint though I am inclined to think that the yellow-fever question is settled. The discovery that it is the mosquito alone that conveys the disease will enable us to manage it.

I cannot but think that the freedom of Havana from yellow fever on the 24th of August, a thing never before known, must be due to the fact that we got the infected mosquito nearly every time. The disease has been introduced freely from the outside, and yet has not spread among our thirty thousand non-immunes. I believe that our system gets them nearly every time. I think we will soon have Santiago de las Vegas under control. We are inspecting and keeping track of all the non-immune travelers coming to Havana. They are seen by one of our doctors every three days of their stay in Havana, up to six. We have gotten hold of several in this way, and the town is being regularly gone over with the same system that we have in Havana.

We had a case on the 20th from Las Vegas, but it was from a part of that town that had not been disinfected. I feel confident that we will have no more cases from Las Vegas after Sep-

tember 1st. This will be a very nice demonstration of what can be done by our system of mosquito killing.

Heretofore we have disinfected exactly as last year, plus using the pyrethrum powder and oil in the infected house and in all the neighboring houses. Formaline was used in the infected room and the clothing was sent to Las Animas Hospital, and the patient quarantined. I did it because it could not decrease the effectiveness of disinfection, and would relieve me from criticism in case we were not able to control yellow fever, and had as much as we had last year.

I must confess that our results this year are entirely unexpected to me, and if I had any idea how they were coming out I might have discontinued the disinfection of clothing long ago. But in order that the cases may be reported as generally as possible, I am doing everything that I think I safely can to make the routine as little burdensome to the people, as possible. In accordance with this, I have this month issued an order that in yellow-fever cases the only disinfection was to be with pyrethrum; that the clothing was not to be taken to Las Animas, and that after the fifth day the patients were not to be quarantined or screened.

I have been designated by the Military Governor to represent the Department at the Public Health Association next month at Buffalo, and also the Board of Health at the meeting at Niagara which is scheduled to occur on the 13th. I hope to see you there if I go. If things are as quiet as they are now, I will probably go; but if I have any

yellow fever on hand I would rather send somebody else.

Yes, I agree with you. I think this yellow fever work will reflect great credit upon our corps. Certainly the work of proving the mosquito to be the transmitter of yellow fever is as important a piece of work as has been done since Jenner's time, and as far as the United States is concerned, probably of more importance; and as yours was the guiding hand in the whole matter, I hope that some suitable reward will come to you, more substantial than the general professional recognition which you are now getting from all quarters. I am very happy to shine in the more humble rôle of being the first to put your discovery to extensive, practical application.

Mrs. Gorgas joins me in kindest regards.

Very sincerely yours,

W. C. Gorgas,
Major & Surgeon, U. S. A.,
Chief Sanitary Officer.

(9)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, Sept. 2, 1901.

My dear Gorgas:

Upon returning to town, from a two weeks' rest in the mountains , I find your very interesting letter of Aug. 26th. Of course, Carroll had already written to me about the unfortunate termination of

some of Guiteras' cases. I was very, very sorry to hear of Guiteras' bad luck and can appreciate fully his mental distress over this loss of life. Perhaps, after all, the sacrifice of a few will lead to the more effectual protection of the many. I think that we had best look at the matter in this light. That eleven mosquitoes could and did infect *six* persons, causing the death of three, is indeed, very strong confirmatory evidence of our observations of last fall and winter. I have been particularly anxious to learn of your results at Santiago de las Vegas, hoping to incorporate them in a paper on the prevention of yellow fever, which I hope to read at Buffalo; but since the good news comes that you will be there "in persona vera," you can give the figures better than anyone else. I will, however, show by chart, the occurrence of yellow fever in Havana during the present year, and would be so glad if you would give me your cases and deaths for *August.* To Aug. 26th, you report only *two* cases. Were there any others? I have the cases and deaths for the other months. Is not the record a *glorious* one? But it would not have been obtained by a less energetic and enthusiastic Health Officer. You, therefore, my dear Gorgas, deserve all manner of praise for your thorough work. I hope that Carroll is meeting with success. Please let me hear from you by return mail, if possible, about your *August* cases and deaths. A line will do. With kindest regards to Mrs. Gorgas,

Sincerely, your friend,

REED.

(10)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, October 3rd.

MY DEAR GORGAS:

I have been hoping to see you and Mrs. Gorgas in Washington and wondered what you found at Buffalo to keep you so long; but a letter from Carroll just received, mentions your return to Havana. So you have, indeed, given us the "glad go-bye!" Well, as Columbia has just *won* from Shamrock, I'll have to forgive you this time! But you mustn't do so any more, or there will be "trouble on the old man's mind."

I trust that you found the yellow-fever situation satisfactory. I wish that I could have known the No. of cases and deaths for September, so that I could have included them in our paper, but it is too late now. Don't forget to keep me on your exchange list. I had a letter from your brother in answer to one I wrote you for which please give him my best thanks. You were saying, if I remember, that you would like to have your former assistants, Lyster and Shockley, back again. If you haven't them, and still want somebody, I only mention the fact that Asst. Surgeon Devereux, who has been on duty with Borden at the Genl. Hospital here, leaves in a day or two for Havana, to report for duty, and might suit you very well as an assistant. . . . Borden says that he has made a very good assistant. You might have your eye

open for him. Give my kindest regards to Mrs. Gorgas. Good-bye.

Sincerely, your friend,

REED.

(11)

Havana, Cuba., Oct. 8, 1901.

MY DEAR REED:

I was sorry that I did not see you before leaving Buffalo, and have an opportunity of talking with you over your superb paper, and arguments with Wadsin. Nothing could have been clearer, it seems to me. I congratulate you upon being the First Vice-President; I think you ought to have been President but that matter had been arranged beforehand as going to the retiring Treasurer, who had held that office so long. Other names as First Vice-President had been proposed to the Committee, but when your name was mentioned, they all voluntarily withdrew, and you were nominated without a single dissenting voice.

You will see from the report how we are coming along. The record is just as good; two deaths for September. We have had a little focus about the "Mercado del Vapor," but I think we have squashed it. Our last case occurred Sept. 26th. Ten days without a case, this time of the year, is pretty good. But our general death rate took a most remarkable drop. We had only 339 deaths in September, a rate of 15.64 per thousand.

You had better move down to Havana with your family. I am getting so that I am afraid to go

back to the United States and run all the risks of infection and bad hygiene that you are constantly subjected to in cities such as Washington, New York, etc.

I looked into it carefully, and am positive that there is no error in the figures. I don't believe it is possible for a person to be buried in Havana without my knowledge, and I know that these figures are correct.

Carroll seems to be hard at work; looks very mysterious, and can't get him to tell anything. He had better hurry up; yellow fever in Havana will soon be a thing of the past.

I left Mrs. Gorgas and Aileen in New York, but expect them to leave for Havana, Wednesday, the 9th.

With kindest regards, I remain,

Yours very sincerely,

W. C. Gorgas,

Major & Surgeon, U. S. A.,

Chief Sanitary Officer.

Major Walter C. Reed,

Office of the Surgeon General,

Washington, D. C.

This case which I report on September 26, 1901, was really the last which occurred in Havana. Of course we did not know it at the time, but this case marked the first conquest of yellow fever in an endemic center; the first application of the mosquito theory to practical sanitary work in any disease.

(12)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, Oct. 17, 1901.

MY DEAR GORGAS:

I have yours of the 8th inst., and appreciate very much your kind words about my paper and my selection for First Vice-President of the Association. The latter was a very great surprise, as I didn't dream that I would be considered as a candidate for any office.

. . . . . .

I am indeed delighted to hear that you only had two deaths in September. What could be more satisfactory? Certainly *five* deaths in *seven* months is a good record for the city of Havana, in this year of our Lord 1901! I hope that you no longer destroy fomites but are careful to protect your cases until fever subsides or death ensues. Good luck to you and your work! I really don't blame you for being a little nervous about your health when you come to the United States, for you are certainly making Havana one of the healthiest cities in the world. I think that I will take your advice, come down and build me a house; that is, *after* I retire! Remember me very kindly to Mrs. Gorgas and your daughter. . . . I will be glad to get your monthly report for September.

With best wishes,

Sincerely yours,

WALTER REED.

(13)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, Dec. 21, 1901.

MY DEAR GORGAS:.

Many thanks for your October report. The November report has not been received yet, but hope to get it later. I got your kind letter of Dec. 6th. Certainly the results for October and November could hardly be beaten. I think that we should thank Heaven and be satisfied. Another experimental case of yellow fever? Look here, Mr. Sanitary Officer, if you don't stop applying stegomyia to willing Castilians, there will be trouble yet! Carroll fairly grinned all over when I read it to him! He wishes to be very kindly remembered to you. I am glad that Dr. Finlay still finds his Tetragenus. Please remember me to him. What a splendid paper that was of Guiteras in *American Medicine!* I was delighted with it. Make my best regards to him, also, please. The weather here is so very cold that I long for the balminess of the Cuban atmosphere. Why men and women will persist in living in cold climates is something that I can't possibly understand. Stay where you are. Don't permit even the evacuation of the Island to bring you away. We need you as a defence against yellow Jack! Well, the hour is five P. M. and all have long since left the office. I must hurry home in an open street-car and thereby chill my very marrow. My best regards to Mrs. Gorgas. . . .

With all manner of greetings for a Merry Xmas and happy 1902, believe me,

Sincerely, your friend,

REED.

(14)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, Jan. 14, 1902.

MY DEAR GORGAS:

In response to your request just received, I have forwarded to you a copy of each of our Reports which I will ask you to hand to the French Consul with my compliments. I was just about to write to you, to ask at what time during 1901 you omitted to disinfect bedding or clothing. I think that you wrote that about August 15th, you no longer required such disinfection, but I cannot find your letter. Again: Can you not give me some of the data with regard to your fight for control of the epidemic in Santiago de las Vegas? Did your results show by the prompt suppression of the epidemic in that town that you were adopting the right measures? I have just been asked to write an article for the English *Journal of Hygiene,* setting forth our observations, as well as the work of the Medical Department in Cuba, and I should like to mention Santiago de las Vegas as well as Havana, giving you, of course, full credit for the results obtained. I haven't your December report as yet. Please send me a copy of it. I never was quite so busy in all of my life and sigh for the 3d of April, when I can get this class off my hands.

How is your epidemic in Havana? How I would like to run away from my present surroundings and go on a "toot" with you and Kean!

Please let me hear from you promptly, as I must prepare my paper by the end of February. Remember me very kindly to Mrs. Gorgas. . . .

Sincerely yours,

REED.

(15)

Havana, Cuba, January 22, 1902.

Major Walter Reed,
Surgeon General's Office,
Washington, D. C.

MY DEAR REED:

Yours of January 14th received. The sending of clothing and bedding for disinfection to Las Animas, in yellow-fever cases, was stopped about . The official order was issued August 21, 1901. We have a large disinfecting plant at Las Animas to which everything of this kind is sent. When a house is disinfected for diphtheria or any similar disease, the room itself is infected with formaline gas and washed down with a bi-chloride solution "and all fabrics and clothing of every kind are sent to the disinfection plant. Up to the time mentioned this had been done in the case of yellow fever, but, having become convinced that the mosquito was the only way of transmitting the disease and that no good could be obtained from this process, we stopped this method.

From my experience here in municipal sanita-

tion, I think this is of the greatest importance, viz: to put people to as little inconvenience and loss as possible by methods of disinfection. The destruction of mosquitoes in a building can be accomplished with very little annoyance to the inmates but the thorough destruction of fomites causes a great deal of inconvenience and some loss.

The all important matter in yellow fever is to get your cases reported as thoroughly as possible and this can only be done with the co-operation of the people. I am therefore of the opinion that the great element of our success was due to the fact that we did away with the attempted destruction of fomites. You can readily see how one unreported case might start an epidemic.

The Santiago de las Vegas case is a very good illustration of the efficiency of our methods in stamping out a focus. Santiago de las Vegas is practically a suburb of Havana, distant about twelve miles with a considerable non-immune population, constantly having communication with Havana. The infection of 1900 evidently remained over. Some cases occurred in January, some in June and more in July. The cases of July were taken and the houses all gone over, and the mosquitoes killed, but it was evident that the infection had gotten away from us by this method, so on the 24th of July we got a considerable appropriation and started a brigade systematically fumigating, block by block, around the infected areas. With this we were successful and got rid of the focus. This was the most difficult disinfection we have attempted. The infection

had evidently got pretty widely spread and new cases kept occurring outside of the area in which we were working. I send you a few papers on the subject. Please return them when you have finished as they form a part of our records on the subject. Please excuse this hurried letter.

Sincerely yours,
W. C. GORGAS,
Major and Surgeon, U. S. A.
Chief Sanitary Officer.

(16)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, Jan. 31st.

MY DEAR GORGAS:

Your kind letter of January 22d was received a few days ago. I am very much obliged for the information concerning Santiago de las Vegas. I have made a copy of several of the enclosed papers and return them herewith with many thanks for the opportunity of seeing them. I would like to know in how many cases of y. f. since July 1, 1900, you have omitted disinfection of clothing. How many cases under observation in Havana since that time? There were five deaths I notice after that date and these probably cover say twenty cases. Can you give me the exact number of cases by months for 1900 and 1901? I want to make a curve for these years of cases to accompany my next article to be published in the *Journal of Hygiene* (English). . . .

Another thing. Can you possibly obtain from Dr. Guiteras, some eggs of stegomyia and send them to me dried on filter paper? I have no insects nor eggs at present, and am so very anxious to obtain some as soon as possible.

Remember me very kindly to Mrs. Gorgas. With best wishes,

Sincerely yours,

WALTER REED.

(17)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, Feb. 4, 1902.

MY DEAR GORGAS:

Yours of January 31st is just to hand. The Army Examining Board of which I am a member is not now in session, but undoubtedly will be set at work just as soon as the school session ends, April 3d, and I should venture the opinion that the Board will remain in session until November 1st, except during a brief summer vacation in July and August. I hope that your friend will appear. Give him a note to me, or a general recommendation for the use of the Board, and I will see if I can't soften the hearts of some of the stoniest-hearted members. . . . I hear that you are going to have a y. f. "picnic" down in Havana this month. Talk "right from the shoulder" to those South Americans, and make them begin the work of exterminating the disease in their respective coun-

tries. I think that Mexico is alright on this question.

. . . . . .

Faithfully yours,

REED.

(18)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, Feb. 12, 1902.

MY DEAR GORGAS:

Just a line to say that I have your kind letter of Feb. 6th, containing the information that I so much wanted. I thank you very much for it. I am trying very hard to put together an article for the *Journal of Hygiene,* as I wrote you, but between the class and other work, it's deuced hard to accomplish a half hour's work on it daily. Did you see Souchon's reply to Carroll and myself in the Record for January 8th? . . . If I can get a little time, after awhile, I may reply to him. . . . This should reach you in the midst of the meeting of the Congress. Do, pray, persuade them to accept the mosquito transmission and change their sanitation accordingly. I trust to you, Havard, Kean and Guiteras to do this. Make my kind regards to Mrs. Gorgas. I am so glad that you are going to remain in Havana for awhile. You should stay during the whole summer and fall. . . .

Good-bye.

Sincerely yours,

REED.

(19)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, April 3, 1902.

My dear Gorgas:

Yours of March 28th reached me yesterday. . . .

I was simply delighted with your Annual Report. What a glorious record! No wonder, my dear boy, that you should grow eloquent, as you did, in your closing paragraph. It made my heart beat faster as I read it. You have done a splendid work in Havana, my dear Gorgas, one that should always give you the greatest pleasure to look back upon. You have my sincere admiration and congratulations. *We will really and truly have to go on that Toot when you land on your native heath, once more! !* But if I had my way, you would remain in charge of sanitary matters in Havana for another summer! I have told Gen. Sternberg so. It would be such a pity to have this splendid work all undone, for the lack of an enlightened Health Official. Who will succeed you? His position will be the most important on the Island. . . .

Adios, my dear friend. May Heaven bless you.

Your friend,

Reed.

(20)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, May 14, 1902.

MY DEAR GORGAS:

I received your reprints and was very much pleased with them and to know that you are doing such good missionary work. Modification of quarantine will come slowly but surely. Am delighted to know that you will be here on your way from Saratoga. . . .

So you have really applied stegomyia again to y. f.? Dear me! Haven't you had experience enough? If you are going to do this thing much more, Carroll and I will join you on your way back to Havana. There are several problems to be worked out, from a scientific point of view. . . . Are you not a delegate to the Assoc. of Military Surgeons? I though that you were. If you should arrive before May 28th, you could join us in the dinner to Gen. and Mrs. Sternberg. Wish so much that you could be here with Mrs. Gorgas, as I know that you would both enjoy the occasion. . . .

Sincerely yours,
REED.

(21)

War Department, Surgeon General's Office,
Army Medical Museum and Library,
Washington, July 21, 1902.

MY DEAR GORGAS:

It was like the good fellow that you are to sit

down and write me that nice letter of congratulation. Harvard did indeed do me very great honor in conferring the degree of Master of Arts, and the audience was so very enthusiastic that I felt that Boston, at least, had some appreciation of what the Army had done in Cuba. . . . The University of Michigan, not to be outdone by Harvard, gave me the following week the degree of L.L.D! . . .

There is another way in which to look at this matter. Instead of simply being satisfied to make friends and draw your pay, it is worth doing your duty, to the best of your ability, for duty's sake; and in doing this, while the indolent sleep, you may accomplish something that will be of real benefit to humanity and worth more than all the high places that could be bestowed by shrewd politicians. Nor you nor I have reason to be ashamed of our work of the past two years, nor would we think of exchanging places with any of the luckier members of the Corps. *"Verbum sap."* I am having Mr. Meyers look up Panama and Nicaragua literature. Do you want articles in German and French, or only in English? How shall they be addressed?

With warmest regards to Mrs. Gorgas, . . . believe me, always,

Your good friend,

REED.

CHAPTER VIII

HISTORY OF YELLOW FEVER

FROM the dawn of history man has made some attempt to prevent disease. He saw on all sides evidences of the fact that he had suffered from disease through no fault of his own; that occasionally disease would occur with unusual violence and exterminate whole communities.

The cause of such mortality not being evident to his senses was attributed by him to spirits, or to powerful gods. These spirits being superior to himself in power, he attempted to propitiate them by presents and prayers. These were his first efforts at preventive medicine and sanitation. He would try to drive off the evil spirits of disease with loud and disagreeable noises made by tom-toms and similar instruments. He attempted to prevent the ingress of these same spirits by signs and incantations. The gods were looked upon as beings influenced by the same love and passions as himself, and he appealed to them with

supplications or bribes, as seemed likely to be most effective. In his reasoning during this barbarous age concerning the cause of disease, he was really nearer the truth than subsequently during a much more refined age, or even up to the middle of the nineteenth century. We now know that spirits and gods do not directly cause disease in man, but we have found out that living beings, germs, are the direct cause of all infectious diseases.

A great many of our sanitary measures, if now witnessed by our ancestors of three thousand years ago, would probably seem perfectly natural and proper. The fumigation of ships and buildings would seem a very proper mode of burning incense to the hostile god who was causing yellow fever. The modern man, his descendant, is burning the pyrethrum to kill the living spirit, the mosquito, which he has found by experiment really causes the disease. Our ancestor would accept as a perfectly natural explanation the use of oil on the stagnant waters if he were told that this was a libation to propitiate the angry god who was inflicting on man malarial fevers. His descendant is using the oil really to kill the living beings, mosquito larvæ, which cause malaria.

As man advanced in intelligence and civilization he threw aside his belief in spirits and numberless higher beings as causes of disease among his fel-

lowmen. He now began to attribute disease to abnormal conditions in the blood and tissues of the body, caused by unfavorable environment, such as filth, food, clothing, climatic conditions, etc. His efforts for the prevention of disease during all this period had little or no effect. It is probable that through long ages the human race remained stationary in numbers or increased very slowly, due principally to the fact that men were unable to affect favorably their sanitary condition, or to ward off in any way the fearful epidemic scourges that every now and then swept through the ranks of mankind.

Up to the time of the discovery of America, Europeans had been making no attempt whatever to prevent dsease and with our present knowledge and point of view, we can see that any sanitary attempt on their part would necessarily have failed. They had an entirely wrong conception of disease and an erroneous theory of its cause. The mortality rates in most parts of Europe at this time were as high as its birth rates. In England, the population had not increased for several centuries, or if it had increased, the increment was so slight that it could not easily be measured. Every now and then virulent epidemics would sweep through Europe and carry off a large portion of the population. The figures as given in some of these epidemics are almost inconceivable.

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HISTORY OF [illegible]

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For instance, it is stated by Hecker that the epidemic of plague in the fourteenth century carried off from Europe some twenty-five millions of the population, and from China alone, thirteen millions. That again, in the fourteenth and fifteenth centuries, millions of the population of Germany and other countries were carried off by the "sweating sickness."

Such instances of mortality could be adduced ad infinitum. Leprosy in the fourteenth century was more common in England than it is now in Palestine, so common that every county had a lazaretto where lepers were strictly confined, and laws are still on the statute books prescribing the method of their confinement, and the disposition of their property.

The inhabitants of Europe at this time were subject to all the contagious and infectious diseases to which, with one or two exceptions, they are now subject, but most of these diseases, for some reason, were vastly more virulent than they are at the present time.

In the fifteenth century when America was discovered by the Europeans, the Indians undoubtedly suffered from disease. They probably had some diseases from which Europeans, up to that time, had not suffered, and the Europeans, no doubt, brought with them some diseases from which the Indians had not suffered. Yellow fever

is a good example of the first, and syphilis of the second. And this must necessarily have been the case if we give a little thought to the matter.

According to generally accepted scientific belief, the buffalo developed from the first created cell from which we have all descended. If his ancestry could be traced, the line would run straight back to this first cell. But he developed into the present buffalo in a limited area in North America. The ox, at some period in the distant past, branched off from the same line of descent from which the buffalo came, yet he developed into the present ox within a very limited area in Central Asia. These animals were originally native to a very small area of country, and this seems to have been the case in the development of all animal life.

The yellow-fever germ is primarily an animal very much like the buffalo or ox, and must have come from the first created cell just as did all life, and must have developed as did other animals in a very limited area or territory. Exactly the same could be said of the tuberculosis germ. It is, therefore, just as natural that the western hemisphere should have had its peculiar diseases as that it should have had its peculiar animals.

Everywhere that the European attempted to colonize he suffered from disease, and this always occurred within the first two or three years. In

Columbus' settlement on Santo Domingo, he lost within the first three years a very large number of the colonists settled there. When the English colonized Virginia at Jamestown, they lost from disease about one-half of the total number of colonists, and the same is true of the settlers at Plymouth. Everywhere that settlements were attempted, the settlers were so nearly destroyed by disease that, in many instances, the few survivors could not be persuaded to remain.

Yellow fever is an acute specific, very fatal, febrile disease, lasting about a week, and characterized by fever, vomiting, muscular pains and albuminuria, and in the graver cases by black vomit and hematogenous jaundice. It is transmitted from person to person by the female stegomyia mosquito. The sick person does not infect the biting mosquito after the third day of the disease. One attack gives immunity against a second attack.

Like all other diseases, its origin is enveloped in a cloud of obscurity. The yellow-fever organism, like the horse or the dog, developed in some particular locality. The horse had his whole lifetime in which to wander from place to place, and so spread very rapidly and widely as compared with the yellow-fever organism. The yellow-fever organism was dependent upon the mosquito and man for his locomotion. On the average, he

had not more than a week in which to travel. I presume that a week would be long for the average life of a stegomyia mosquito, and the traveling ability of the organism would be limited by the life of the mosquito. For while the female stegomyia mosquito has to live two weeks after she has bitten the yellow-fever patient before she can convey the disease to another non-immune human being, still the average length of life in the mosquito cannot be as great as this. The various conditions of unfavorable environment, the natural enemies of all kinds, wind, etc., must kill a large proportion of mosquitoes within the first week. If we consider the total number of stegomyia mosquitoes in an infected locality, we must see that only an infinitesimal proportion succeed in biting a yellow-fever patient within the first three days. This small proportion, however, has the best protection and is more likely to have a long life than the average of the female stegomyia, for they necessarily bite inside of the houses, and in such places have the best protection from the wind and sun, their greatest enemies.

In this other host, man, the parasite had only three days to travel. During these three days the man would be sick and not likely to move about much. During man's savage state he traveled very little more than did the mosquito. We would expect, therefore, the yellow-fever organism's

rate of spread to be very much less rapid than the spread of the horse.

When America was discovered, the horse had not yet reached that continent. The evidence with regard to the yellow-fever organism seems to me to indicate that, at this same time, it had not spread further than a limited area about Vera Cruz. It is probably the latest disease to which man has been subject.

There are very many beliefs as to the locality at which yellow fever developed; that it originated among the earliest nations of the world inhabiting Asia Minor; that it originated in Africa in connection with the slave trade; that it originated in America, and was not known to Europeans until the discoveries of Columbus.

A recent writer on yellow fever, Augustin, suggests that its origin can be traced back to the siege of Troy, and that the Greeks and Trojans suffered severely from this disease during the prosecution of the war. Mr. Augustin argues quite forcibly in favor of the idea that many of the great epidemics of Europe and Asia, before and since the Christian era, were yellow fever. He thinks that the population became immune from the fact that all at some time suffered from the disease, and thus, in the course of time, it died out from want of material on which to feed. I consider Mr. Augustin one of the most compe-

cent authorities that we have on the history of yellow fever, and anyone writing on that disease in any of its phases would do well to consult his monumental work.

It seems to me, however, that the evidence is against yellow fever having occurred in Europe before the fifteenth century. If it had been general in southern Europe, semi-tropical Asia Minor and semi-tropical Africa, it would be there now, just as it is in similar localities in tropical and semi-tropical America. If the Phœnicians had suffered from yellow fever during the time of Abraham, and the great epidemics of Smyrna, Thebes, Athens, Rome and Carthage had been yellow fever, this disease would be in those countries now. History does not show that yellow fever can immunize a whole country, but merely the locality in which it prevails endemically. While the old inhabitant of Havana was immune to yellow fever, the man from the interior of Cuba where yellow fever had not been endemic knew that he was just as liable to contract yellow fever when he visited Havana as was the man who came from the United States, and he feared the disease just as much.

The native of the city of Panama was immune to yellow fever, but the soldier coming from the mountains of the interior knew that he would catch the disease, and this actually occurred

many times whenever a fresh regiment was brought to Panama. At present, Guayaquil in Ecuador is the seaport of Quito, the capital of the country. Quito is situated some three hundred miles up in the mountains, and is connected by rail with Guayaquil. Yellow fever is at present endemic in Guayaquil and has been so for many years. The old resident of Guayaquil is immune to yellow fever, but the natives of Quito dread Quayaquil as they do death. They never go there when they can avoid it, and when they have to visit the outside world, they remain in Quayaquil just as few hours as will enable them to catch their ship. And the fear is well founded. Very many Ecuadorians of high position have lost their lives from yellow fever contracted in passing through Quayaquil. But all these years of endemicity of yellow fever in these cities, the inhabitants of the respective countries in which they are situated have never become immune.

The same is true of Europe, Asia and Africa. If Memphis, in Egypt, had been an endemic center of yellow fever in the dim dawn of man's civilization, the disease would be endemic there at present. While the native of Memphis who labored on the pyramids of Cheops would have been immune to yellow fever, enough fresh material from up the Nile would have continued coming into Memphis to have kept the disease going.

And the hundred thousand men whom old Cheops kept at work on his pyramids for twenty years would have died in such numbers that he would either have had to give up this work, or would have exhausted the population of his kingdom; but the interior of Egypt would never have become immune any more than has the interior of Cuba, or Panama, or Brazil in our own time.

Had Athens been subject to yellow fever in the time of Alcibiades, yellow fever would certainly be there to-day. All the citizens of the city of Athens would have become immune, but a sufficient number of Greeks would have been constantly coming into the city from the interior to have kept the disease endemic, exactly as has occurred in our own time at Havana. I think, then, that we can throw aside Europe and Asia as the original source of yellow fever.

Another theory of the origin of yellow fever is that it originated in Africa and was carried to America in connection with the slave trade. Next to that of the origin in America, this is the most generally accepted explanation. But the arguments against this belief are unanswerable.

According to Lind, the first yellow fever that appeared in Africa was in Senegal, in 1759. If yellow fever had existed along the coast, it would certainly have spread in the two hundred and fifty years during which this coast had been oc-

cupied by Europeans since its settlement by the Portuguese in the year 1415. As a matter of fact, it was recognized many times in America before it appeared in Africa. The American origin of yellow fever impresses me as being the most reasonable and the one most in accord with the recorded facts. But it seems to me that the bulk of evidence points toward its having originated in America at some period prior to its discovery by Columbus.

Dr. Carlos Finlay, in a paper published in *The Climatologist,* of Philadelphia, in July, 1892, gives very clear proof that the disease existed in America before the discovery by Columbus. It seems to have been endemic in the neighborhood of Vera Cruz, Mexico, and to have been very well known to the Aztec authorities. The Government, before the arrival of the Spaniards, had many times caused a forced emigration from the interior to the neighborhood of Vera Cruz, to repopulate a country that had been depopulated by an epidemic disease known to the Aztecs as "cocolitzle." To induce them to stay, these people were given many privileges, such as exemption from taxation, etc. This cocolitzle was known among the Mayos of Yucatan as "black vomit." The Spanish historian, Father Lapey, gives a very clear account of cocolitzle as it occured in Yucatan in 1648. It is such a clear description

of yellow fever that I think it instructive to quote from his report as given in Dr. Finlay's paper:

With such violence and rapidity were the people attacked, big and small, rich and poor, that in less than eight days the whole population of the city (Campeche) were sick at the same time, and many citizens of the highest rank and authority died. In most of the cases the patients were taken with a most severe and intense headache, and pains in all the bones of their bodies, so violent that their limbs felt as if torn asunder, or squeezed in a press. A few moments after the pains, there came on a very intense fever, which in most instances produced delirium, though not in all. This was followed by vomiting of blood, as if putrified, and of such cases very few survived—and many suffered the fever and pain in the bones without any other symptoms. In the majority the fever seemed to remit completely on the third day; they would say that they felt no pains whatever, the delirium would cease, the patients conversing in their full senses, but they were unable to eat or drink anything; they would continue thus for several days, and while still talking and saying that they were quite well, they expired. A great number did not pass the third day, the majority died on the fifth, and very few reached the seventh. The most healthy and robust of the young men were most violently attacked and died soonest. When the laity began to improve, the disease broke out among the priests. Of the eight members of the Jesuit Col-

lege, six died; of our own order (Franciscan) twenty died in the city. Almost all the heads of institutions and persons of highest rank, both ecclesiastics and seculars, were carried away by the epidemic. The disease continued over the whole country during the space of two years. Few that then lived in this land, or visited it, in the course of those two years, escaped being sick, and it *rarely happened that anyone died of a second attack after having recovered from the first.* I then reflected that of the young children who were attacked by the peste in Yucatan, only few had died, as compared with the adults.

CHAPTER IX

GEOGRAPHICAL LIMITS OF YELLOW FEVER

THE geographical limits of yellow fever, when first encountered by the white man, were not very wide. They were contained within a zone limited on the north by the twentieth parallel of latitude, on the south by the eighth, on the east by the sixtieth meridian, and on the west by the one hundredth. Practically, the disease was confined to the shores of the Caribbean and the southern shores of the Gulf of Mexico. Within these regions it was practically endemic at the time Columbus discovered America. The arrival of the white man with his sailing ships made the disease much easier of transmission from place to place, because man traveled much more frequently and much farther, and also because sailing ships, with their fresh-water tanks, bred the stegomyia extensively. Under these influences the endemic area began slowly to spread. Toward the north the endemic area never extended far beyond the

limits it occupied when Columbus made his first voyage. Havana, in latitude 23°, is the northern endemic limit in the western hemisphere. This is rather strange, as the city is located so near the original endemic focus. The arrival of a considerable number of non-immunes in a locality is necessary for yellow fever to become endemic, and this supply has to be fairly constant. During the first hundred years after the founding of Havana, in 1511, the city was considered very healthy. In 1620, an epidemic of yellow fever occurred, the disease having been introduced from Panama (Porto Bello) by the treasure fleet on its way to Spain. In 1649 another epidemic occurred, which was extremely severe and spread to many other towns of Cuba. This epidemic lasted more or less until 1655. For a hundred years after this, nothing in the nature of an epidemic occurred. In 1762, at the time of the capture of Havana by the English colonial troops from the North American colonies, the disease again became epidemic, and after that time remained constantly in Havana as an endemic disease. At this time it was recognized as being introduced from Vera Cruz, Mexico, under the name of "black vomit." It became endemic, and did not disappear as on former occasions, on account of the large and constant supply of non-immune persons, due to the presence of the Eng-

lish troops, and after their departure, to the fact that the port was thrown open to general commerce, and to a continuous supply of immigrants from Spain.

It would seem, then, that Havana, after remaining in the epidemic area for some two hundred and fifty years, finally, about the year 1762, passed permanently into the endemic area.

Havana is the most northern point to which the endemic area ever extended. Toward the south the endemic area spread much farther from the original endemic focus than on the north. While in distance from the original endemic area the disease spread further south than north, it did not in point of latitude. Rio Janeiro and Santos, the furthest points south to which the endemic area spread, are about latitude 23°, much the same as Havana on the north. Para, Manaos, Pernambuco and Bahia gradually came within the endemic area, until finally, in 1849, yellow fever took up its permanent habitat in Rio and Santos. During the year 1850, forty-one hundred and sixty persons died of yellow fever in Rio.

These cities, like Havana, were subject to epidemics of yellow fever years before they became endemic centers. Endemicity did not spread regularly over this area from north to south. The disease became endemic in Rio thirty or forty years before it did in Manaos. Other factors

proved more potent than location as to latitude. The large emigration to Brazil, which set in about the middle of the nineteenth century, gave a constant and large supply of non-immunes to Rio, while Manaos did not get this supply until railroad construction commenced in the interior, about the beginning of the present century.

Strictly speaking, Pernambuco, on the eastern coast of Brazil, about longitude 35° west, is the point farthest east where yellow fever really became endemic, in the sense of remaining continuously in one city for a number of years. But on the west coast of Africa, from St. Paul de Loanda on the south to the Canary Islands on the north, yellow fever has been present all the time at some point or points, ever since its introduction in 1494, though on this coast it has never manifested itself continuously in the same town or city for any considerable number of years. But it is endemic on the coast in the sense that it no longer has to be re-introduced from the outside, but is always present at some point. We have a pretty accurate account of its first introduction into the Canary Islands in 1494 by Spaniards returning from Hispanola.

The farthest point west at which it has ever become endemic is its original home, Vera Cruz, Mexico. It has been endemic at both Panama and Guayaquil, on the west coast of America.

While these points are on the west coast, and Vera Cruz is on the east coast, still, Vera Cruz is some sixteen degrees of latitude west of either Panama or Guayaquil.

The endemic limits of yellow fever at its period of greatest extent would be defined by a line drawn from Havana, commencing on the north, to the Canary Islands, down the west coast of Africa to Loanda, from Loanda west to Rio Janeiro, Brazil, from Rio Janeiro to Guayaquil, Ecuador, from Guayaquil to Panama, from Panama to Vera Cruz, Mexico, and from Vera Cruz back to Havana, a very restricted area compared with other infectious diseases.

But it is as an epidemic disease that it has caused most alarm and loss. The United States, Spain, and the West Indies have suffered most severely in this respect. It has been epidemic as far north as Quebec in North America. In 1805, some fifty-five cases occurred among the English troops stationed there. In Europe, it has been epidemic as far north as Swansea, Wales. In the year 1865, the sailing ship *Hecla* from Cuba, introduced yellow fever into Swansea, and twenty-two cases developed in the town in persons who had no communication with the vessel.

France has never had a yellow-fever epidemic of any consequence, though it has been demon-

strated that under favorable conditions, the disease might become epidemic. At St. Nazaire, in the year 1861, yellow fever was introduced by the sailing ship *Anne-Marie,* and forty cases resulted, with twenty-three deaths.

Yellow fever has appeared in epidemic form several times in Italy, but has never extended further east. Leghorn is the most eastern point to which yellow fever has ever reached. There in 1804 a severe epidemic occurred in which some two thousand persons died.

On the west coast of Africa epidemics have occurred as far south as St. Paul de Loanda. The island of Ascension, about the same latitude as St. Paul but in the mid-Atlantic, has suffered very severely. In 1823, the British sloop *Bann* brought yellow fever from Sierra Leon to Ascension. Ninety-nine cases occurred on the *Bann,* with thirty-four deaths, and on the island itself twenty-eight cases occurred with fifteen deaths.

Yellow fever has been epidemic on the east coast of South America as far south as Montevideo, and on the west coast as far south as Valparaiso, and on this same coast as far north as Guaymas, Mexico.

The epidemic area of yellow fever has been very much more extensive than the endemic area. This epidemic area would then be bounded by a line commencing on the north at Quebec, Canada,

extending east to Swansea, Wales; from Swansea south to St. Nazaire, France; from St. Nazaire southeast to Leghorn, Italy; from Leghorn south to Loanda, on the west coast of Africa; from Loanda west across the Atlantic to the island of Ascension; from Ascension still west across the Atlantic to Montevideo; from Montevideo still west across South America to Valparaiso, Chili; from Valparaiso northwest to Guaymas, and from Guaymas northeast back to Quebec.

By lines of latitude and longitude the epidemic area would be bounded on the north by the forty-fifth degree, north latitude; on the south by the thirty-fifth degree, south latitude; on the east by the tenth degree, east from Greenwich, and on the west by the one hundred and tenth degree, west from Greenwich.

In point of area its period of greatest extent was during the first half of the nineteenth century. Since the middle of the nineteenth century its area has been decreasing rapidly, until at the present time this disease is confined to a half dozen centers in South America.

Within the epidemic area the loss of human life from this disease has been very great, the United States and Spain being the most populous countries affected.

South America lies generally well east of North

America, and its northern coast is about opposite the southern part of North America, so that the neck of land which connects the two runs east and west and is known as the Isthmus of Panama. Most of this isthmus is embraced in the present Republic of Panama.

Columbus was the first white man to visit Panama. On his third expedition he entered the Bay of Bocas del Toro, and spent some time there. On this same expedition he also visited Limon Bay, into which the northern end of the Panama Canal at present empties. He also visited Porto Bello, which afterwards became rich, famous and populous, and which is located on the northern extremity of the royal paved highway running north from the old city of Panama. He left more than one hundred men under his brother, Diego, at Belen, some fifty miles west of the present town of Colon. After several years of sickness, hardships and deprivations, this colony was finally destroyed by the Indians. Spain afterwards ennobled Columbus' grandson, Luis, under the title of Duke of Veragua, and granted to him a large tract of land in the neighborhood of this old colony, to which was given the name "Dukedom of Veragua." One of the provinces of the Republic of Panama which covers about the same area as did the tract referred to, is known as the Province of Veragua. The old royal highway

just referred to, running between Panama and Porto Bello, lies from five to fifteen miles east of the Canal. Columbus' third voyage was made in 1498. A few years later, Balboa, with a party of Spanish adventurers, under the authority of the Captain-General from Santo Domingo, arrived in the eastern part of Panama and made permanent settlements, at first on the north coast, and discovered the Pacific.

A few years later, in 1519, the city of old Panama was founded. Balboa was the best type of the Spanish conquistador. He was brave, hardy and determined, qualities very common to the early Spanish adventurers, but Balboa was more able and had much broader views of government and colonization than either Pizarro or Cortez. He was displaced as governor of Panama by Pedrarias, a man inferior to him in every respect. Balboa was beheaded by Pedrarias in 1517. He had heard of the Inca empire to the south, and was getting together a fleet on the south coast with the intention of invading this empire. Pedrarias became jealous of his power, and feared he was getting together a force for the purpose of overthrowing his government. As far as historical data show, there was no reason for this jealousy.

Tradition has it that the cause of the enmity between Balboa and Pedrarias was due to the fact

that Balboa, being betrothed to the daughter of Pedrarias, became involved in an affair with the daughter of an Indian chief while absent on the south coast building the fleet with which he hoped to conquer the Inca empire. Pedrarias' daughter, hearing rumors of this affair, became very jealous, and influenced her father's mind against Balboa, even to the extent of having him beheaded. This is, however, probably pure romance.

The facts seem to be that Pedrarias, being a narrow-minded man and jealous in disposition, gradually became hostile to Balboa on account of the latter's popularity with the Spanish colonists, as well as with the Indians. Balboa, for a conquistador, was humane in his attitude toward the Indians. For this reason Pedrarias began to make charges against and quarrel with Balboa. Pedrarias, being governor, had absolute power in the Province of Panama, and Balboa, to be successful in fitting out his expedition, knew that he had to have the support of Pedrarias. In his endeavor to placate him and insure his support, Balboa married Pedrarias' daughter, a child of six years of age. The marriage ceremony was performed by proxy, Pedrarias' daughter being absent in Spain. Balboa never saw his wife.

Pizarro was one of the lieutenants of Balboa, though as an officer of Pedrarias' government he was actually in charge of the party that ar-

rested Balboa. Balboa's death was a great loss to Spain and to Panama. He would in all probability have made a much more humane conqueror of Peru than did Pizarro, and certainly would have made a much abler ruler of that country. He was beheaded at Acla, the capital of Panama at that time, situated on the north coast on Caledonia Bay. All trace of this town has now disappeared.

Panama when first known to the Spaniards, in the early part of the sixteenth century, was a thickly inhabited country, peopled by a mild-mannered Indian population, who lived principally by agriculture. Las Casas makes the statement that during the twenty years in which Pedrarias governed Panama he caused the death of three million Indians. I am inclined to think this a very great exaggeration, but it is evident from the accounts one reads of Balboa's expeditions that there was a considerable population in the country. As day after day he makes marches from town to town, Balboa describes getting supplies from these towns, and that he was able to procure from five hundred to a thousand porters for carrying the baggage of the expedition. In every town he secured some gold, and none but a very populous country could have furnished the supplies of men and amounts of gold which he describes.

The Republic of Panama is something over half the size of the state of Alabama, containing some 31,571 square miles of territory, and is divided into two parts near its center by the Panama Canal. The western half contains at present all the population of the Republic. The eastern half has no population at all, with the exception of a few wild Indians. In Balboa's time this eastern half was thickly populated, and contained most of the inhabitants. Columbus looked upon Panama as the richest portion of his American discoveries, particularly from a gold-producing standpoint, and the Spaniards generally shared this opinion. This was such a widespread belief that the country was known as Castilla del Oro.

The importance of Panama was vastly increased by the discovery and conquest of the Inca empire about 1530. Vast quantities of gold and silver bullion passed through Panama on its way to Europe. It seems to be an historical fact, mentioned by Prescott and other writers, that Pizarro exacted from the Inca emperor, Atahuallpa, for his ransom, a room full of gold, the dimensions of which are stated as being twenty-two feet long, seventeen feet wide and nine feet high. An adjoining room of somewhat smaller dimensions Atahuallpa agreed to fill twice over with silver. Such quantities of bullion were introduced into Europe as had never before been

dreamed of, and prices rose to what was then considered an extraordinary figure.

The city of Panama became the commercial metropolis of the western hemisphere. The highway between Porto Bello and old Panama became a road over which there was a constant stream of people traveling. All the merchants, officials and colonists going to Peru, western Mexico, and the Spanish possessions in the East Indies used this route, and there was a steady and constant stream of such people going between the colonies and mother country.

About the beginning of the seventeenth century Panama was the chief port for the Spanish trade of the Pacific. This large travel and large business was fortunate for her from a commercial point of view, but it was the cause of her evil reputation as to health. Her location was in the tropics, where the stegomyia mosquito could breed freely all the year round. Yellow fever was early introduced by the Spanish conquistador. Then the constant stream of unacclimated Europeans passing for four hundred years through her borders made conditions ideal for the development and maintenance of yellow fever. And for four hundred years this region has been known as the most unhealthy in America.

As Panama grew in wealth and importance, and it became known what great amounts of

treasure were passing through her borders, she became attractive to the English soldiers of fortune. Drake was one of the earliest of these, and his name and fame are intimately associated with the early history of Panama. He first came to the north coast in 1572, and remained in the country nearly two years. He secreted his ships in remote places among the beautiful San Blas Islands, and it was not discovered by the Spaniards just where he was. From this point he made frequent expeditions against the various Spanish possessions.

From Drake's accounts there was still a considerable Indian population in the country, though not by any means as numerous as in Balboa's day. This Indian population was bitterly hostile to the Spaniards, who, whenever they could get hold of them, were their harsh and cruel taskmasters. Consequently, the Indians were friendly to the English whom they knew to be the enemies of Spain.

CHAPTER X

APPOINTED CHIEF SANITARY OFFICER FOR THE ISTHMUS

EARLY in the year 1902, while still stationed at Havana, I wrote to Surgeon-General Sternberg concerning the discoveries made by the Reed Board, and the application made of these discoveries to the eradication of yellow fever in Havana, and invited attention to the fact that they would have a most important bearing upon the work of the construction of the Panama Canal.

I invited General Sternberg's attention to the enormous loss of life that had been caused among the French working at Panama, due to tropical diseases; that by far the most important of the diseases were yellow fever and malaria; that if we could protect our laborers on the Canal as we had the people of Havana, we should be able to build the Canal without anything like such losses as had occurred to the French. I also invited his attention to the fact that while there was a considerable difference in the conditions and environ-

ment at Havana, still I believed that the methods worked out at Havana could be so modified as to be applied successfully at the Isthmus.

General Sternberg approved the idea, and recommended that, on account of my experience in similar work at Havana, I be placed in charge of the sanitary work on the Isthmus.

In all discussion with regard to canal construction at this time Nicaragua was looked upon as the point where the United States would build its canal. Delays entirely unexpected to the authorities occurred on account of the failure of the treaty with Colombia, and it was not until the fall of 1903 that it was settled that we were to build a canal at Panama, under a concession from the Republic of Panama.

I was relieved from duty at Havana in the fall of 1902 and ordered to the United States, in order that I might be in personal contact with the preparations for canal work on the Isthmus. While waiting for the organization to commence, I was sent to Egypt as the representative of the Medical Department of the United States Army to the first Egyptian Medical Congress, and I was directed while on this duty to examine into what had been the sanitary conditions during the construction of the Suez Canal.

This turned out to be a very interesting trip, though I did not get much information that was

useful to us at Panama. The conditions were so entirely different at the Isthmus of Suez from the conditions at the Isthmus of Panama from a sanitary point of view that there was no similarity in the sanitary measures applicable to the two places. The route of the Suez Canal was through a dry, sandy desert, where, at the time of construction, they suffered from neither yellow fever nor malaria. The route of the Panama Canal lay through a low, swampy country, alternating with rugged mountainous regions, where the rainfall was excessive, and yellow fever and malaria prevailed to an alarming extent.

During my visit there, however, I found that they were suffering severely from malaria at Ismalia, a town on the canal about halfway across the Isthmus, and the headquarters of the Canal Company. During the early period of their construction work they had a great deal of trouble supplying their laborers with drinking water. They were obliged to carry this on camel-back a number of miles from the nearest branch of the Nile. I was informed that, at one time, they had to employ some sixteen hundred camels in this work.

In order to obviate this expense and inconvenience, De Lesseps reopened the old canal of the Israelites, leading up from the Nile through the land of Goshen. This old canal came within a few miles of the present route of the Suez Canal.

The French extended it to the Suez Canal, and then made a small canal parallel with the route of the Suez, which conveyed fresh water all along this route. Wherever in the desert fresh water is applied to the soil, the land becomes very fruitful and productive. At Ismalia, this sweet-water canal, just described (the Arabs usually refer to fresh water as sweet water), was used for irrigation purposes. When I saw the canal in 1902, the town and neighborhood were covered with a beautiful growth of trees and shrubbery, and vegetation appeared on every side. Unfortunately, the water which produced this wonderful oasis in the desert also bred the malarial mosquito freely and Ismalia had become a hotbed for malaria.

Sir Ronald Ross, the great English sanitarian, who had taken so prominent a part in discovering that malaria was carried by the anopheles mosquito, was employed by the French Company to advise them how they should protect themselves against this plague. The plans which he advised were carried into execution, and Ismalia in a short time was entirely free from malaria.

When I returned from Egypt, I found the canal project still being delayed. Pending organization, I was sent to Paris, France, as the representative of the United States Army Medical Department to the Hygiene Congress which met in Paris in

October, 1903. I was directed to get while there such sanitary information as might be obtained from the Paris offices of the French Panama Canal Company. Besides having a very agreeable and delightful stay, I collected a great deal of valuable data with regard to the sanitary conditions which had existed under the French at Panama.

Finally, in January, 1904, the Isthmian Canal Commission was organized by the President under the Spooner Act. The President was very strongly urged by the medical profession generally to make a medical man one of the commissioners. It was pointed out to him that sanitation at Panama was fully as important as engineering; that if our force suffered as much from disease as had the French fifteen years before we should have great difficulty in carrying through our project. His attention was invited to the fact that in this Commission of seven men, where the sanitary phase of the work to be controlled by them was just as important as the engineering phase, there were five engineers and not a single physician.

The American Medical Association took a most active part in urging this matter upon the attention of the President, and hundreds of telegrams came in to him on this subject from all parts of the country. The President was not convinced by these arguments as they were presented to

him, and organized the Commission of seven members without putting a physician on it.

During the latter part of March, 1904, I was ordered to accompany the Commission to Panama as their sanitary adviser, and for the purpose of drawing up a scheme of sanitation whereby the force might be protected during the construction of the Canal. I requested that Medical Director John W. Ross, United States Navy, Major Louis A. La Garde, Surgeon, United States Army, and Major Cassius E. Gillette, Corps of Engineers, United States Army, be detailed to assist me.

We went to Panama with the Commission, and were absent on this trip about a month looking into conditions and examining the locality. After much study and careful consideration, we submitted a report which embodied the organization which we thought necessary to accomplish the desired ends. The report also gave detailed estimate of the cost of this organization.

The French Company still had possession, and their representatives were in charge when we made this visit. They treated us very hospitably, and we were their guests during our stay on the Isthmus. We were housed on the Atlantic side, in the building known as the De Lesseps Palace. There was, however, nothing palatial about this building. It was simply a good, comfortable, frame building, such as can be found on many of

the well-to-do plantations in our southern states. De Lesseps is accused of having erected it at a cost of more than $100,000. As I afterwards came to be more familiar with the history of the French régime at Panama, I found that this was on a par with most of the other stories of French extravagance on the Isthmus, and had no more foundation in fact than many of the other tales that fill the books of a few of our American writers concerning the Canal, to the discredit of the French.

On one occasion we were invited across the Isthmus to dine with the Administrator who was in charge of the work. It is somewhat startling to an inhabitant of the United States to contemplate traveling from the Atlantic to the Pacific to keep a dinner engagement, but at Panama this was not unusual. We not only left the Atlantic in the afternoon and dined on the shores of the Pacific the same evening, but we returned from the Pacific and slept on the shores of the Atlantic that same night. I was familiar with the history of the house in which the French Director lived, where we dined that night. I could not help recalling the sad story of Monsieur Dingler, the great French Director, who first attempted canal construction on the Isthmus. In this house had died his wife, daughter and son-in-law, and scores of other French engineers of prominence. The French butler who waited on us at dinner that

evening and presided over the servants who attended us, remained with the Americans in the same capacity during the whole period of construction on the Isthmus, and is still there as the major-domo of the Chairman of the Isthmian Canal Commission.

We spent a delightful evening, and returned to the "North Sea" after dinner, reaching Colon about one o'clock in the morning. An amusing incident of our stay on the Isthmus occurred on our return. One of the commissioners was sick, and for this reason did not attend the dinner. In my business of looking up sanitary matters at Colon I had come to know the Mayor of the town quite well. Much to my surprise I found him at this late hour of the night awaiting our return. He took me aside and told me in a whisper that the Commissioner whom we had left behind sick had appeared on the street most uproariously drunk, had fought the Colon police to a finish, and was at that moment in the Colon jail raising pandemonium. The Mayor said that he had endeavored in every way to keep the matter quiet and protect the honor of the American Commission, but that the Commissioner himself had been so noisy and pugnacious that he feared the matter had gotten pretty well noised about the town.

I was, of course, much chagrined at this account of the Commissioner's conduct. I knew well his

reputation in the United States, and knew that he had lived a perfectly correct life for fifty years, enjoying the respect and consideration of the community, and that at home he was known as a sober and abstemious gentleman as far as alcoholic drink was concerned.

I took the Chairman of the Commission aside and unfolded to him the astounding story which the Mayor had just confided to me. We got into a carriage with the Mayor and hurried to the jail. As we neared this building our worst fears were confirmed; pandemonium seemed let loose. We could hear our honored Commissioner swearing and shouting, to the great delight and amusement of the crowd outside. We hurried in to see what we could do with our friend. Upon being ushered into the room in which he was raising such an uproar, we found that it was not the Commissioner, but one of our clerks. He had developed delirium tremens as the result of too much French hospitality, and insisted that he was the Commissioner above mentioned. The Mayor was never quite convinced that this was not the case. The Commissioner rather rose in the estimation of the townspeople, as being a jolly good fellow, but the Mayor always thought that he had carried things a little too far for a man occupying such a dignified position.

In April, 1904, I was finally ordered to report

to the Commission as the chief sanitary officer for the Isthmus. Having been there, we had a very good idea of how great the difficulties would be in getting either supplies or personnel. We therefore requested the Commission to authorize our taking down a certain number of men and a certain quantity of supplies. They authorized our spending $50,000 for these purposes, and this we did, taking the men and supplies with us to the Isthmus early in June, 1904.

As I have before stated, when we visited the Isthmus in March, 1904, the French were still in possession of the property and we were their guests. On May 4, 1904, the property was formally transferred to the representatives of the United States, so that when we reached the Isthmus in June we were at once able to take possession of such sanitary equipment as there was, and to begin our organization.

CHAPTER XI

PRELIMINARY ORGANIZATION AND WORK AT PANAMA

FROM the very beginning insuperable difficulties arose in the way of getting supplies. Very little could be obtained on the Isthmus, and the supply departments in the United States were so slow in being organized that, during the first year, very few requisitions that were sent to the United States were filled.

The attempt of the first Commission to manage from Washington the work at Panama in all its details was fatal, and the arrangement whereby the Sanitary Department was made one of the bureaus of the Government, having no access to the Chairman, the real executive, except through the Governor, was equally fatal. In June, 1904, however, we all commenced work with a great deal of enthusiasm, determined to do the best we could under the circumstances.

The $50,000 worth of supplies taken down, and the personnel brought along at the same time, en-

abled us to make a good start in all branches of the Sanitary Department, as outlined in the recommendations made in March. If it had not been for the supplies and personnel taken down at this time, we could have made no better showing than did the Engineering Department or the Quartermaster Department during the same period.

We realized that the subject of yellow fever was by far the most important phase of sanitation with which we had to deal. We appreciated that, if the Americans were subject to this disease to any considerable extent, we should have great difficulty in keeping them at Panama, and in order to induce them to stay, we should have to increase wages to such an extent that the cost of the work would be very greatly increased. That even if we should find a white American force which would be willing to stay, and if we could afford to pay sufficiently high wages to induce them to stay, Congress, in all probability, would not sanction the continuance of the work, if we lost from yellow fever fifteen or sixteen hundred Americans every year.

From the best statistics which I could get on the Isthmus, I found that the French lost yearly by death from yellow fever about one-third of their white force. If we lost in the same ratio it would give us about thirty-five hundred deaths among our Americans yearly. We, therefore, dur-

ing the first year made yellow fever the first consideration, and gave it the most attention.

The two principal foci of infection for yellow fever were the towns at either end of the railroad, Colon at the northern end, on the Caribbean Sea, and Panama at the southern end, on the Pacific Ocean.

As I have mentioned in a former chapter, when we got through at Havana, we all thoroughly believed that the great virtue of our work there lay in the killing of infected mosquitoes by fumigation. So when we commenced work in the city of Panama, we relied principally upon this method. We carried fumigation in Panama, however, much further than we had ever dreamed of doing at Havana. Beside carrying out the method which we had developed at Havana of fumigating the house where a case of yellow fever had occurred, together with all the contiguous houses, we adopted the following plan.

Panama compared with Havana was a very small town. Havana in 1904 had a population of 250,000; Panama, about 20,000. Instead of waiting for the slow process of fumigating the house where a yellow-fever case occurred, with the contiguous houses, and thereby killing the infected mosquitoes concerned in that particular case, we ought to be able, we said, in a small town like Panama to fumigate every house in the city within

Screened Yellow-fever Ward. Ancon Hospital, Panama.

St. Charles Ward, Ancon Hospital. Building in Which Twelve Hundred Frenchmen Died of Yellow Fever.

a comparatively short time, and thereby get rid of all the infected mosquitoes at one fell swoop.

This would certainly have been the result if our premises had been correct, namely, that it was the fumigation that had caused the disappearance of yellow fever at Havana. With this object in view, we commenced at one end of the city and fumigated every building. It took us about a month to get over the whole town. Cases of yellow fever still continued to occur after we had finished. We therefore went through the procedure a second time. Still other cases occurred, and we went over the city a third time. We used up in these fumigations in the course of about a year some hundred and twenty tons of insect powder, and some three hundred tons of sulphur. These quantities of material give some idea of the amount of fumigation.

This draft of one hundred and twenty tons of insect powder represented the whole supply of the United States for a year, and we actually used up at Panama all the insect powder that could be found in the market of the United States.

An interesting incident occurred during this first year with regard to insect powder. Knowing that there would be some yellow fever to be dealt with in Colon and Panama, we estimated and made requisition for eight tons of insect powder. The reviewing authorities were very much shocked

and surprised at the size of our requisition, and seized upon this one item of eight tons of insect powder to demonstrate the wildness of our estimates. It was some satisfaction to us for the Commission to see that we had not only not been wild and extravagant in our estimates, but that we had been obliged to use actually fifteen times as much as we had estimated for.

From the very beginning the Commission underestimated the magnitude of the sanitary operations, as well as their cost, and when the sanitary authorities urged upon them more extensive preparation and larger expenditure, they thought us visionary and more or less lost confidence in us. This was very unfortunate both for the sanitary authorities, and for the Commission, and came very near being the cause of the complete collapse of sanitation.

General George W. Davis, the governor, was the only member of the Commission who lived continuously on the Isthmus. He was the only member of the Commission who had any adequate idea of the difficulties with which the Sanitary Department was confronted. He gave us his heartiest support.

Our force of unacclimated whites liable to yellow fever rapidly increased during the winter of 1904 and spring of 1905. Yellow fever increased with still greater rapidity. The authorities became

more and more alarmed. In January, 1905, the first Commission was asked to resign, and a new Commission was appointed.

Even after this change the Sanitary Department was in no better condition than it had been under the former Commission. The chief sanitary officer was still subordinate to the governor of the Canal, and had no means of access to the chairman, except through the governor. Such sanitary measures were carried through the importance of which the chief sanitary officer could impress upon the governor. Those, the importance of which the governor could not see, were with great difficulty carried into effect.

This condition of affairs was unfortunate. The authorities had no sanitary training, and as they looked upon the ideas of the sanitary officials with regard to the method of conveyance of yellow fever by the mosquito as being wild and visionary, they could not be expected to have rose-colored views as to what would be the results of attempting to carry these views into effect.

The sanitary authorities had no doubt of their ultimate success, and felt confident that they could eradicate yellow fever in Panama, as they had just done in Havana, if they could only hold on long enough and get reasonable support from the superior authorities.

Conditions with regard to yellow fever kept go-

ing from bad to worse during the first six months of 1905. In April, 1905, several of the higher officials died of yellow fever. This caused widespread panic among the whites, and very great demoralization to the work itself. A considerable sprinkling of our white force had either been in Cuba with us, or knew what had been accomplished there with regard to yellow fever, but the rank and file of the men began to believe that they were doomed just as had been the French before them.

Finally, in June, 1905, the Governor and Chief Engineer, members of the Executive Committee of the Commission, united in a recommendation to the Secretary of War that the Chief Sanitary Officer and Dr. Carter and those who believed with them in the mosquito theory, should be relieved, and men with more practical views be appointed in their stead. They stated that the sanitary authorities had visionary ideas with regard to the cause of yellow fever, and no practical methods even for carrying these ideas into execution.

Fortunately for the cause of sanitation, the then President of the United States had been in office when the work at Havana had been done by us. He told the Commission that the mosquito theory had been established beyond peradventure; that its application had been entirely successful at Havana, where yellow fever had been more firmly

established and established for a longer time than at Panama. He declined to sanction the change recommended, and directed that every possible support and assistance be extended to the sanitary officials. It was really fortunate for the sanitary work that matters were brought to a head in this way.

Mr. John F. Stevens about this time was appointed chief engineer and member of the Commission, to fill a vacancy which had been caused by the resignation of the former Chief Engineer. From his arrival on the Isthmus Mr. Stevens expressed confidence in the Sanitary Department, and gave us his undivided support. The moral effect of so high an official taking such a stand at this period, when the fortunes of the Sanitary Department were at so low an ebb, was very great, and it is hard to estimate how much sanitation on the Isthmus owes to this gentleman for its subsequent success.

During the fall of 1905 the Chairman of the Commission recommended that the Sanitary Department be made an independent bureau, reporting directly to himself. This enabled the chief sanitary officer to make known directly to the chairman of the Commission the needs of the department. The chairman, also, when thus informed of our needs, gave us loyal support.

This period was the high-water mark of sanitary

efficiency on the Isthmus, and more sanitation was done at this time than during any other period of the construction of the Canal.

During the fall of 1905 yellow fever rapidly decreased, and by November, the last case of this disease had occurred in Panama. This fact quieted alarm on the Isthmus, and gave the sanitary officials great prestige, not only among the now large body of Canal employees, but also among the native population living on the Isthmus.

In looking back over our ten years of work, these two years of 1905 and 1906 seem the halcyon days for the Sanitary Department. It was really during this period that our work was accomplished. By the fall of 1907 about all of our sanitary work had been completed. Our fight against disease in Panama had been won, and from that time on our attention was given to holding what had been accomplished.

One more case of yellow fever occurred in Colon during the following May, but since May, 1906, now more than eight years, not a case of yellow fever has originated on the Isthmus.

It is interesting to speculate upon what might have been the result if the recommendation in regard to changing the sanitary officials had been carried into effect. At that time, in June, 1905, most of the physicians who had had experience with yellow fever had not been won over to the

truth of the theory of its transmission by the mosquito. It was reported on the Isthmus that one of the most prominent and ablest of these physicians, who did not believe that the mosquito transmission of yellow fever had been proved, and who was convinced that he himself had controlled yellow fever acting upon the filth theory of its causation, had been settled upon as my successor. Had this been the case he would undoubtedly have stopped mosquito work and devoted his attention entirely to cleaning up, as is indicated by the filth theory of the causation of the disease. He would have been the more inclined to this course, as it accorded with the beliefs and prejudices of the authorities on the Isthmus.

This would probably have been kept up for two or three years, and there is no reason for believing that our condition on the Isthmus in 1908 would have been any better than was that of the French at the height of their work, when they were having a death-rate of 250 per thousand per year of their employees.

It would apparently have been demonstrated that nothing could control yellow fever on the Isthmus, and the belief then generally held that it was the most unhealthy place in the world would have been still further confirmed. And while it is probable that eventually the mosquito theory of yellow fever would have become established

somewhere else, its apparent failure at Panama would have given it a blow from which it would have taken years to recover.

It seems singular that, after the demonstration at Havana, there should have been any doubt in the mind of anyone with regard to the mosquito transmission of yellow fever.

Moreover, the reputation of Dr. Carter, Dr. Ross, Mr. Le Prince and myself, as sanitary officials, would have been irretrievably ruined. We took a tremendous risk and came very near failing from causes hinted at in the foregoing pages.

Even if the dangers had been as great as they were under the French, and the deaths as numerous, I believe we would have found a sufficient number of men who were willing to go to the Isthmus, just as did the French. There is always a certain element which is attracted by danger and adventure, and to whom exposure to risk is a sufficient reward for their labor. This characteristic I have always found particularly strong among the Americans. But if we had lost from disease thirty-five hundred of our Americans every year (for the French lost in about this ratio), I am inclined to think that public opinion would not have backed any work involving such loss of life, and that Congress would not have made the appropriations for continuing the work.

CHAPTER XII

YELLOW-FEVER WORK AT THE ISTHMUS

AT the same time that yellow-fever work was commenced, an attack was also made upon malaria. Mr. Joseph L. Le Prince, who was in charge of similar work in Havana, was placed in charge of this work.

The anti-malarial work in the towns of Colon and Panama was exactly similar to that in the city of Havana. But the country along the line of the Canal between the two termini, Colon and Panama, was entirely different, and the problem was much more extensive than it had been in Havana.

The anopheles, the malarial mosquito, is peculiarly a country mosquito. In general, he likes clear, fresh water in which grass and algæ are plentiful, such as is found along the banks of the small mountain streams of Panama, or the fresh water ponds and pools. The grass and algæ give protection to the larvæ from the fish. Wherever

the small fish can easily gain access, there mosquitoes cannot breed.

For the purpose of looking after malaria along this fifty miles of country district, the region was divided into twenty-four sanitary districts, known as Panama, La Boca, Ancon, Corozal, Miraflores, Pedro Miguel, Paraiso, Culebra, Empire, Las Cascadas, Bohio, Matachin, Gorgona, Juan Grande, San Pablo, Tabernilla, Frijoles, Largarto, Lion Hill, Gatun, Mount Hope, Colon, Nombre de Dios and Toro Point. Some years after, when the railroad was being relocated, we had an additional sanitary district, embracing the town of Lirio and a working force in that neighborhood for several miles up and down the road. Later, a quarry was established at the old city of Porto Bello, for the purpose of getting stone for the Gatun locks, and here we had another sanitary district.

Porto Bello is about twenty miles north of Colon, on the Caribbean Sea, and in our time was accessible to Canal employees only by water. It was the northern terminus of the old royal highway, built by the Spaniards in the sixteenth century, and a good road at that time. This road had become entirely overgrown and was impassable even to a man on foot. It was originally well paved and well graded. I spent a great deal of time in trying to cross the Isthmus on this road, and succeeded in getting as far north from Pan-

ama as San Juan, a town of about one thousand inhabitants, on the Pequini River, and on the royal road about half-way across the Isthmus. There had been some travel between this town and Panama which had kept the royal highway sufficiently open to be traversed by pack animals. The Alcalde, a man of about seventy years of age, told me that no one in his memory had crossed on the road from San Juan to Porto Bello.

Porto Bello has a beautiful landlocked harbor, decidedly the best for hundreds of miles up and down the Caribbean coast. This coast is not subject to hurricanes and severe storms of that kind, but during the winter months the north wind, locally known as a "norther," blows sharply for several days at a time, and makes it very uncomfortable for vessels lying in the open roadsteads which characterize all the other harbors. Two or three times every winter all the vessels lying at the docks in the harbor of Colon have to get up steam and go to sea on account of the severity of these northers. The harbor of Porto Bello is entirely protected from these northers by a mountain which runs out into the sea. Behind this mountain is a spacious and deep harbor.

About the beginning of the seventeenth century Porto Bello enjoyed one of the largest export trades in the then commercial world, though it was never a very populous town in its halcyon

days, probably not having more than fourteen or fifteen thousand inhabitants, and this only during the period when the great fair was going on. As soon as the fair was over, the population dropped to a couple of thousands.

Professor William R. Shepherd, of Columbia University, estimates that the bullion shipped from Porto Bello amounted to about forty-two million dollars ($42,000,000) per year. If we take into account the value of gold then as compared with the present time, we can see that the export commerce of Porto Bello during the sixteenth century and early seventeenth was very little under two hundred million dollars ($200,000,000) per year.

Porto Bello had such a reputation for bad health that merchants, shipmasters, sailors and everybody got away as soon as possible after the fair was over. Indeed, I have seen it stated that it was the health conditions that limited the length of the fair; that the shipmasters would stay as long as they had crew enough to work their ships. When sickness had reduced the crew to the minimum which was able to work the ship, the shipmaster sailed away and thus broke up the fair.

Porto Bello was established by royal decree when the Spaniards abandoned Nombre de Dios, a town on the Caribbean coast about twenty miles east of Porto Bello. Porto Bello was strongly

fortified by the Spaniards. Four different large and extensive stone forts were erected at various points about the harbor. These masonry structures were considered very strong for their day, and were well armed and well manned. One of the largest was built well up the side of the mountain which formed the protection for the harbor on the north, and where we afterwards established our quarry, above referred to.

Drake in his last expedition attempted to capture Porto Bello. He was repulsed in his attempt to storm the forts, but succeeded in capturing the Spanish fleet in the harbor. He died in the harbor of Porto Bello a few days after the fight, January 28, 1596. His followers placed his body in the flagship of the Spanish fleet, took the ship to the mouth of the harbor and there scuttled her. The island at the mouth of the harbor is still known locally as Drake's Island. I cannot imagine a more appropriate burial place for Drake than this spot, nor a more fitting tomb than the Spanish flagship. For this was the scene of some of his greatest triumphs over the Spaniards.

Morgan, about seventy years later, succeeded in storming the forts and capturing the town, and Admiral Vernon again captured it in 1730.

In its prosperous days Porto Bello was every fall the scene of the great fair. This was one of the great fairs of the world. The merchants from

Spain and Europe, Cuba and Santo Domingo brought their goods to Porto Bello, and at the same time the Spanish treasure fleet collected here for the purpose of starting on its trip to Spain. The merchants from Peru and all the western coast of South America, the western coast of Mexico and the Philippine Islands collected here for the purpose of purchasing from and exchanging with their confrères from the east. All the bullion, gold, silver and precious stones which had been collected at Panama during the year from these same places was now brought on pack mules across the Isthmus on the royal highway, and placed aboard the treasure fleet. The royal highway was not much used at other times; the ordinary route of travel across the Isthmus was north from Panama to Cruces on the Chagres River, and from the mouth of the river by sea to Porto Bello. But this thirty miles of sea trip exposed the traveler to possible capture by the buccaneers who infested these waters. The ordinary merchant, in ordinary times, was willing to take these chances, but when it came to the Imperial treasure collected for a whole year, and to the whole year's supply of merchandise, they would not risk the attack of the buccaneers, but came across the old highway.

Porto Bello rapidly lost its importance after the revolt of the Spanish colonies in the early part

of the nineteenth century. There was no longer any treasure tribute to be shipped to Spain. The building of the railroad in 1855 entirely deprived Porto Bello of the little importance left it by the Spanish colonial revolution, and when we first occupied it, we found nothing but a fishing village of a couple of hundred natives, who lived by fishing and some agriculture. There was a very marked contrast between the squalid native and the carved stone building which made his residence. The walls of many of the public buildings and some of the more opulent private buildings are still standing, and are used by the natives. And the frowning old forts are in an excellent state of preservation.

We placed a large force here which worked the quarry. At first our malarial rate was excessively high, but in a very few months malaria was controlled and the force here got along about as well as at the other places of employment. It was always the case that when our forces occupied a locality, for the first three or four months the malarial rate was high. Of course we could have avoided this if we had been notified two or three weeks beforehand and had sent up a sanitary force to do preliminary work, but such notification was not always possible in the exigencies of construction work.

Porto Bello at first gave us considerable anx-

iety; we knew its ancient history, and feared that we might not be able to control disease there. But the difficulties appeared no greater there than at several other points occupied by us.

Our laborers and working forces occupied the side of the mountain on the north side of the bay opposite the old town of Porto Bello, and the quarry was worked first where the old fort stood. We soon found that our employees were so much in the town of Porto Bello that they contracted malaria there, and that though we were able to control it in our own village on the mountain side, we could not prevent our people from contracting malaria from the natives in the town of Porto Bello. The town was located outside the Canal Zone, in the jurisdiction of the Republic of Panama. We therefore requested the Panaman Government to appoint the chief sanitary officer the health officer of the town of Porto Bello. It had been generally agreed that wherever it was necessary for the protection of the health of the Canal employees the Panaman Government would surrender this authority to the chief sanitary officer of the Isthmian Canal Commission.

We introduced the same health measures as in the other sanitary districts, which we expect soon to describe, and in a few months had malaria here completely under control. Porto Bello was located well within the San Blas country. Though

the inhabitants of the town were Panamanians and recognized the authority of the Republic of Panama, all of the Republic east of this point, in area about one-half of the state of Panama, was entirely uninhabited, except by a few San Blas Indians, not more than thirty thousand all told.

The largest product of these Indians was cocoanuts, and this cocoanut trade employed a considerable number of light draft schooners and canoes. These fleets rendezvoused in the harbor of Porto Bello. They carried on their trade as far east as the Gulf of Atrato, and the city of Cartagena, in Colombia. There was, therefore, a probability of the introduction of infectious disease to the Canal Zone by this route.

To protect ourselves against this disease we had to establish a quarantine station at Porto Bello. The Panaman Government was asked to appoint the chief sanitary officer of the Canal Zone quarantine officer for the port of Porto Bello. This they promptly did.

The San Blas Indians who inhabited this country east of Porto Bello, are a peculiar and interesting people. This was the region first occupied by Balboa and his Spanish companions. They found here a pretty dense population of Indians, Carib in language and probably in descent. Their habits were agricultural and their character rather

warlike. They were thoroughly subjugated and were worked by the Spaniards under their apartamiento system. Las Casas states that the governor, Pedro Arias, during his governorship of some twenty years, caused the death of three million Indians in the present state of Panama. I have no doubt that such a figure is a very great exaggeration, but it shows what a very good old Spanish priest thought of the destruction of Indian life due to the cruelties of the conquistador.

Fifty years later when Sir Francis Drake appeared upon the scene, this Indian population had almost disappeared. Sir Francis Drake, in 1572, secreted his three ships in one of the sheltered and well concealed bays among the San Blas Islands, and marched his one hundred Englishmen through all parts of the present San Blas country. His narrative shows that the Indian population was very much less than that described sixty years before by Balboa, marching through the same country. They had been treated so cruelly by the Spaniards that they thoroughly hated them. As they knew that the English were fighting the Spaniards, they were always ready to help the English and give information.

The governor of Panama, all through the colonial period, was constantly trying to overrun this country, and though at various times forts were built in many localities, and these forts garrisoned

for a considerable length of time, the country was never conquered, and the Indians after their original conquest by Balboa never recognized the authority of the Spaniards. They early adopted the policy of not allowing, under any pretext whatever, a white man to come into their country. This law they have enforced up to the present time, and still enforce it. Many white men have lost their lives in trying to explore the interior of the San Blas country.

For generations there has been a good deal of commerce in light-draft schooners along the northern coast of the San Blas country. The San Blas Indian himself, like all the other Carib tribes, is a natural-born sailor. You see him miles from shore in his frail dugout, in the roughest sort of weather. It has been his custom for generations to ship aboard sailing-vessels visiting his country, occasionally for very long voyages, as far even as London or New York, so that when you meet him, he is very likely to speak English, and on occasions of state, wear European clothes. In the ten years that we have been at work on the Isthmus the San Blas Indians have acquired considerable confidence in us, and have become quite friendly. They come to the hospitals very freely for treatment and surgical operations, and the men can now be seen almost any day in Colon trading. Whenever they come up to Colon, they wear European clothing.

This is of every variety and style, but the hat is always the same, a derby!

The present government of the Republic of Panama has induced the old Chief to recognize formally the authority of the Republic. This has not been brought about by force, but principally by freeing the trade with the Indians of all duties, and by flattering the old Chief.

As an official of the Panaman Government, the Chief is authorized to wear a most splendid gold-laced uniform coat, furnished by the Panaman Government. This will not, however, always retain the allegiance of the old man.

Not very long ago the Panaman Government established a small police station at the extreme end of the northern coast of the Republic. The President of the Republic took occasion to inspect this post, and went down on the only war vessel the Republic possessed, a twenty-ton steam launch. As they passed the island in San Blas Bay on which was located the principal town of the Indians, the old Chief ran up the Colombian flag, and notified the President that he had changed his allegiance from Panama to Colombia. As the old fellow controlled a full quarter of the territory of Panama, this meant a good deal to the Republic, but the President very wisely made no attempt at force. He granted the few unimportant requests of the Indians; increased the old Chief in his rank;

gave him a new coat with more lace than the former, and the flag of Panama now floats serenely where the Colombian flag then floated.

While the Indians recognize the overlordship of the Republic of Panama, I doubt if the President, or any other white official, would be allowed to spend a night in the San Blas country, nor would they during our whole stay on the Isthmus allow any official of the Canal Commission to spend a night in this domain.

Some years ago the Indians reported to me that they had yellow fever among their people, and requested my help. As their territory came directly up to the Canal Zone, it was important for us to know whether or not this was really true. A party of sanitary officials, consisting of Dr. Carter, Major Lyster, myself and others, went down on a steamer to investigate. We went by appointment to the principal town. The Indians were very glad to see us, and received us most hospitably. It was a very picturesque scene as we approached the landing. The whole population was drawn up on the beach in their gala attire, to do us honor. The women, who had probably never before seen a white man, were dressed very much as described by the earlier explorers in the middle of the seventeenth century; a skirt of some bright material and a scarf of brilliant red around the shoulders; gold ornaments in great profusion; nose

rings, ear-rings, heavy bracelets on the upper arm and around the ankles. A most peculiar custom among the young women was that of binding very tightly around the calves of both legs a band of beadwork, from four to six inches broad. Some had the same band on the upper arm. This band had been worn so long and was so tight that it had made a deep, permanent depression in the muscular tissue; enough I should have thought to cause some lameness, but in no case could I see that it interfered with locomotion. The early explorers also refer to this custom.

Another custom which I have seen referred to and which attracted our attention among these Indians, is the manner in which the women smoke their cigars. I saw many of them putting the lighted end in their mouths and smoking the cigar by drawing the air through it that way.

After seeing the display of gold ornaments I could well understand how Balboa collected such large quantities of gold as he describes, in his expeditions through the country. I estimate that the women I saw on this occasion averaged in their rings and bracelets ten or fifteen ounces of gold apiece. The conquistadors, no doubt, when they entered a town seized all this gold.

The Indians, as I have said, received us very cordially, and brought to us all their sick, and apparently wanted us to give some medicine to

everyone in the village. This we cheerfully did, giving them the best advice we could, but when evening came, they politely notified us of their national custom with regard to white men spending a night on shore. We took the hint and returned aboard our steamer.

This disease from which they were suffering we found to be not yellow fever, but pneumonia. While ashore, we had noticed a Jamaican negro paddling around in a dugout. Upon inquiry, we were told that he was our professional rival prescribing various patent medicines for the Indians. A short time after our return to Colon I was told that the custom among the San Blas Indians was to execute the doctor whenever his patient died, and that our unfortunate rival, the Jamaican negro, had been executed for this cause a few days after we left. We had prescribed for one or two patients in the last stages of consumption who evidently had not many days to live. We have, therefore, been very chary about returning to the San Blas country, and strongly suspect that we are marked in the national archives for execution under the San Blas law for the practice of medicine.

The San Blas Indian was very independent in all his ideas, and considered his government as the political equal of the Canal Government, the United States, or any other government.

In looking about for a place in which to get sand to make concrete for the Gatun locks, Colonel Sibert, with a party of engineers, visited this same Chief. They found here what they considered suitable sand, and tried to purchase from the old Chief the right to use it. He was, however, very short with them; told them that the San Blas Indians had need of all the sand the Almighty had given them and hinted very broadly that it would be healthy for Colonel Sibert and his party to return to their boats and leave the country.

CHAPTER XIII

NOMBRE DE DIOS

ANOTHER sanitary district had to be established about twenty miles east of Porto Bello, at Nombre de Dios. Here we had a force of some two hundred men who dredged the sand that was used in making concrete for the locks at Gatun. The conditions were very much the same as at Porto Bello. There was a small native town of not more than one hundred people, on the old site of Nombre de Dios, and we found that to protect our own force we had to take charge of these natives, just as we did at Porto Bello.

Nombre de Dios has even a more romantic history than Porto Bello, and the name of Nombre de Dios is even better known in the wild history of the Spanish Main than is that of Porto Bello. It was founded about 1520, soon after the settlement of old Panama, and became the northern terminus of the paved royal highway leading from Panama. Afterwards, when Porto Bello

was built, the highway forked about thirty miles south of Nombre de Dios, one branch leading to Porto Bello, and the other to Nombre de Dios.

The roadstead at Nombre de Dios was entirely open and exposed to the full force of the north wind, locally known as the "norther," so troublesome along this coast during the winter months. It was so exposed that it was difficult for the Spaniards to fortify it. The fabulous amount of treasure which the Spaniards were bringing up from Peru rapidly became known throughout the world. The Spaniards, during their earlier colonial period, collected their treasure from time to time during the year, in preparation of the sailing of the fleet. For this reason, Nombre de Dios was constantly being threatened by adventurers of all nationalities, who frequented the seas washing the shores of the Spanish Main.

Drake, in his expedition of 1572, made a most romantic attack upon Nombre de Dios. With one hundred men in small boats he attacked the town and took the garrison entirely by surprise. They were driven in every direction and many captured. The Governor, with a handful of men, defended the palace where the gold and more valuable treasures were stored, with desperate valor, but the town and all other public buildings were in the hands of the English, and there seemed very little chance for the Governor and his few

brave followers. The silver bullion, the accumulations of a year from the countries tributary to Spain in this part of the world, was in one of the buildings already in the hands of the English. Drake describes it as being piled in bars of solid silver, and states that the pile was some eighty feet long, twenty feet broad and ten feet high. The old Governor and his companions were still bravely holding the palace, and Drake led a charge in person. While they were battering in the main gate, Drake received a bullet wound in the head and fell to the ground unconscious. His men became demoralized, thinking that he had been killed, and though they had the prize entirely within their grasp, they fled to their boats, carrying with them the insensible form of Drake, and left to the defeated Spaniards the treasure which the English had gone through so much suffering and privation to possess.

The Spanish garrison was immediately reinforced from Panama. Though Drake remained with his ships concealed among the San Blas Islands in the beautiful tropical bay of San Blas, he never had another opportunity of surprising with any chance of success the fort and garrison of Nombre de Dios.

About a year later, however, he surprised and captured a treasure train on the royal highway coming across from Panama to Nombre de Dios.

The fight took place just about where the royal highway to Porto Bello branches off from that to Nombre de Dios. Drake's men after the capture were some fifty or sixty miles from their ships. There was no trail nor road of any kind leading in that direction, so that they could not take the pack mules. Drake therefore directed that the gold and most valuable treasure should be divided up among the men as much as each could carry, and that the silver and least valuable part of the treasure should be buried and concealed as well as it could be in the immediate neighborhood.

Drake and his men succeeded in getting to their ships safely with the treasure they had captured, and this was enough to pay the expense of their whole trip and besides make each one of them rich for life, according to the standards of that day. The Spanish garrison from Nombre de Dios was on the ground within a few hours after the capture of the pack train, and spent several days in searching for hidden buried treasure. They found a great deal, and thought they had found all that was left. About two weeks afterwards Drake and his men returned and dug up enough to give again to each man all that he could carry, but as this was principally silver, it was not so valuable as had been their previous load.

In 1598, Nombre de Dios, by order of the Span-

ish king, was abandoned and everything moved to Porto Bello. As I before remarked, our men were located right among the ruins of the old city of Nombre de Dios, and our sand-digging operations were carried on near the shore line right in front of the town. In the three hundred years since Nombre de Dios had been abandoned the harbor had silted up and filled in to a considerable extent. In excavating for sand our men found the frame of an old ship of considerable size ten or fifteen feet under the surface of the ground, and some two hundred yards from the present coast line. She was evidently an old Spanish ship that had been abandoned at the then shore line of the city of Nombre de Dios, and had gradually been covered by the action of the water with sand and silt.

The Spanish officers and soldiers of 1650 seemed to have lost the initiative and energy which they had so wonderfully exhibited two generations before in this same country under Balboa, Pizarro, Almargo, and other leaders of that stamp. But they did not lack bravery and dogged determination, when it came to the defensive, as was illustrated in the case of the Spanish Governor at Nombre de Dios, when summoned by Drake to surrender, although his condition was apparently hopeless. His courage and devotion were most unexpectedly rewarded by success,

which he had not the slightest right to expect, due to purely accidental conditions.

This bravery and devotion of the Spanish cavalier was again illustrated eighty years later, when Sir Henry Morgan, the English buccaneer, stormed the works at Porto Bello. The circumstances were somewhat the same as above described at Nombre de Dios. The English stormed and carried one stronghold after another until nothing but the palace was left to the Spaniards. In the palace the Governor had placed the women and children, with himself and about ten men, and had barricaded all the entrances as well as possible. He steadily refused all summons which Morgan made on him to surrender. When the main door was battered down and Morgan entered sword in hand at the head of more than one hundred men, he found the old Governor standing with drawn sword, his ten men behind him and the women and children behind them. The Governor was even then a man of over sixty years of age. It was not the custom in those days for either Spaniards or buccaneers to ask or give quarter. Sir Henry Morgan is not ordinarily credited with much soft-heartedness even from the standpoint of a buccaneer. According to accounts, he was touched by the scene that presented itself to his view as he and his men poured into the court—the white-haired old Governor unflinchingly sup-

ported by his brave little garrison of ten men, and the frightened and crying women and children standing behind. By a gesture he waved back his men, and told the Governor that he wished to spare his life and the lives of those dependent upon him. Though his wife entreated the Governor to accept Morgan's terms and pointed out to him the uselessness of resistance, as all the town and the forts were in the hands of six or seven hundred buccaneers, and that there were but ten Spaniards left, the doughty old Governor refused to yield and told Morgan that he was not placed there by his king to surrender, but to fight, and that if he wanted his sword, he (Morgan) would have to take it, as he would never yield it as long as he had a drop of blood left.

This is the only recorded instance that I know of in which Morgan was touched by the bravery of his enemy. But his patience now entirely exhausted, he gave the signal, and in a few moments the brave old Governor and ten of his brave men had gone to the land where the souls of soldiers, good and true, are known to go.

This picture has always affected me strongly. I have often stood on the ground and tried to rehabilitate the old court as it appeared that memorable May afternoon.

CHAPTER XIV

THE WORK OF THE SANITARY INSPECTORS

EACH of the twenty-five districts into which the Zone was divided, as far as the general sanitary work was concerned, was in the charge of a sanitary inspector. The sanitary inspector had under him a force of from twenty to one hundred laborers, with assistants and foremen as necessary. The districts varied considerably in the number of people living in them. Some of the districts had as many as eight or ten thousand people; some only a few hundred. The area of the district varied between fifteen and thirty-five square miles. The Zone extends for five miles on each side of the Canal, that is, a strip ten miles broad and fifty miles long. Most of the population was located on each side of the Canal, within about a mile of its axis, while a few houses and cabins were scattered through all parts of the Canal Zone.

Sanitary work, generally speaking, was done only within a mile or so of the Canal itself. All

brush and undergrowth were cleared within two hundred yards of houses and villages, and the ground carefully drained within the same area. There was no object in carrying sanitary work beyond the populated area. Even if mosquitoes bred where no human beings were living, no harm would be done, as there would be no one to infect.

All told, the country under the jurisdiction of the Isthmian Canal Commission amounted in area to about five hundred square miles, and only a hundred of this was affected by the work of the Sanitary Department. The great work of the sanitary inspector was his anti-mosquito work. In the early days he paid most attention to the stegomyia mosquito, but after the fall of 1905 when yellow fever had been conquered, attention was concentrated on the anopheles, the malarial mosquito.

For the elimination of the stegomyia, the inspector in these country districts took the same measures as described in Colon and Panama against these mosquitoes, though of course on a very much smaller scale. Against malaria, he had a sufficient number of laborers under one or more foremen, according to the size of the district, who cut the brush and undergrowth within two hundred yards of all villages, houses and dwellings, and who also cut the grass within this area whenever it reached a foot in height. This

was done for several reasons. The adult mosquito is destroyed by wind or sunlight, and he seeks all sorts of shrubbery, grass and foliage for protection against both of these enemies. Therefore, if the brush, shrubbery and high grass is cleared off within two hundred yards around a dwelling, there is no shelter for the mosquito from either the wind or sunlight, and there are therefore no mosquitoes within this area.

The anopheles, the malarial mosquito, is not a mosquito of strong flight; two hundred yards is, in general, a good long flight for her. If there were trees and shrubs and bushes every few yards, the anopheles mosquito might travel very long distances and not be much exposed to either the sun or the wind. But if an area of two hundred yards around each building is kept clear, she will not often be able to cross such a zone without destruction, either by sun or wind. Clearing this zone exposes the ground to both sun and wind, and by these forces alone many of the smaller pools will be dried up and made unfit for mosquito breeding. I have often seen this measure alone, that is, clearing the zone, cause a swampy place which I had expected to have to drain, to become dry and cease to breed mosquitoes.

It was also the inspector's duty to see to the drainage. For this purpose he had a properly

Oilers at Work in Marsh.

Burning Out Ditch With Oil Spray.

trained body of men under his control. The drainage was, of course, very much more extensive in area than the grass and bush cutting, for not only had the cleared zone itself to be drained, but all the area within that zone, and also the water-courses leading off from the drained areas had to receive attention. Many times we found that anopheles were breeding very much beyond the two-hundred-yard limit and still coming into the village. In one case we had a very large flight of anopheles which lasted for two or three weeks, and they were found to be breeding more than a mile from the village of Gatun. So, as a matter of fact, our work was very many times carried beyond the two-hundred-yard zone.

The inspector used several methods of draining, being governed in his choice by local conditions.

One of these methods was the open ditch, such as the farmer used for the ordinary draining in agricultural work. At Panama, there were several objections to this method. While the ditch drained the surrounding ground and stopped mosquito-breeding at this point, it became a most excellent breeding-place itself, as the grass grew in the bed of the ditch. At Panama, rain fell daily for eight months of the year, and the temperature was always high enough from one year's end to another to encourage vegetable growth.

The grass, therefore, grew so rapidly that the ditch had to be cleaned out every two or three weeks. The cost of keeping open a surface drain of this kind we found to be very high.

Another system of drainage which the inspectors used very freely and found very useful, was that of filling the ditch, after it had been excavated, with broken stone. This largely prevented the growing of grass, and also prevented any development of mosquitoes in the ditch itself. Another form much resorted to was that of lining the ditch with concrete. This entirely prevented the growth of grass and did away with the expense of up-keep. The only expense involved in caring for such a ditch was that of a man going over it now and then and removing such obstructions as may have gotten in. Mr. Le Prince and his inspectors became very expert in this style of concrete work, and finally, by the use of chicken wire as a framework for strengthening the concrete, were enabled to lay a ditch of this type very cheaply. Wherever the drainage was expected to be used for a year or more, we found it more efficient and economical to use concrete rather than the open ditch.

Mr. Le Prince and his staff devised several processes whereby the cleaning of these ditches of grass was much cheapened. Several solutions of arsenic were found which, when applied to the

grass, killed it. Such a process kept the grass down for a much longer time than that of simply cutting it out with a hoe. A burner was devised which atomized oil under air pressure, making a very hot flame which destroyed the grass roots.

After once clearing a piece of ground the inspector had to keep it in such condition that it would not protect adult mosquitoes. He had, therefore, not only to keep it clear of brush, but also must not allow the grass to grow more than a foot in height. For grass-cutting, there was a great economy in using the horse-mower wherever we could. Numerous open ditches interfered with the use of a horse-mower. To meet this difficulty, the inspector used sub-soil tiled drainage wherever it was feasible. This is the ideal anti-mosquito drainage. It carries off the water, so that there is no formation of breeding-places on the surface. After it is once laid it requires no work or expense for up-keep, and a horse-mower can be used just as freely over its surface as if there were no ditch there.

With the various methods just mentioned we drained pretty well about one hundred square miles of territory, constructing in all some five million feet of open ditch, some one and a half million feet of concrete ditch, some one million feet of rock-filled ditch, and about one million feet of sub-soil tile.

For doing this ditching, each inspector had a gang of men under a competent foreman. In many instances, where the work was extensive and required unusual skill, such as tile-laying, the gangs especially experienced in this work were transferred from district to district. Often it is not possible to drain—for instance, a large swamp area, or where the locality is to be occupied so short a time that it is not economical to drain. In such an extensive engineering work as was being carried out on the Isthmus, the construction work was constantly interfering with the drainage and making pools and puddles which had to be looked after. In these instances, and many others of similar character, the use of kerosine oil was our only resource. The oil was distributed from a can on a man's back, by a pump which he worked with his hand, forcing the oil through a nozzle to the place which he wished to affect. In general, we used crude oil of commerce, not because it was the best, but because it was so cheap that we could use it much more extensively than the rectified oil. It was so thick, however, that we had to thin it with various mixtures before we could spray it through the nozzle. This cost us a fraction over two cents a gallon, and we used about fifty thousand gallons a month over the hundred square miles of territory we were treating. It is not necessary

to look after all collections of water in order that mosquito-breeding may be prevented. If the water is sufficiently deep and clear of grass, so that the fish can have free access, these fish will destroy all the larvæ, and mosquitoes will not develop. But all natural collections of water in a warm climate such as Panama have grass and algæ freely growing on its edges, and these obstructions protect mosquito larvæ, particularly the larvæ of the malarial mosquito, the anopheles.

Gatun Lake, the large lake made by the damming of the Chargres River, gave us a great deal of trouble on this account during the last two years of construction. Not only would the anopheles breed freely around the edges of the lake, but wherever trees or vegetable matter were floating, there algæ grew freely and anopheles larvæ were found in abundance. We found that the anopheles larvæ on the Isthmus developed just about as freely in the mountains as they did in the lowlands. The clear mountain torrent seemed to be just as acceptable a home for the anopheles as the edge of the lowland swamp. At Panama, the temperature remains the same all the year round. The water of the mountain stream is sufficiently warm for his development, just as in the swamp. The stream, as it winds down the mountain, grows grass and algæ freely on both sides of its tortuous course, and here the larvæ of the

anopheles find safe harbor. Into this grass and algæ oil will not spread. We had to find something that would dissolve in the water and poison the larvæ protected by the grass and algæ.

Dr. Samuel Darling, of the laboratory, finally worked out a mixture of carbolic acid, resin and alkali, which would emulsify in water and accomplish this purpose. The mixture was known as larvacide. The method of its manufacture was as follows:

One hundred and fifty gallons of crude carbolic acid are heated in an iron tank having a steam coil, with steam at fifty pounds pressure. Two hundred pounds of finely crushed and sifted common resin are dissolved in the heated acid, and thirty pounds of caustic soda dissolved in six gallons of water are added. There is a mechanical stirring rod attached to the tank. The product is ready in a few minutes, yielding about three and one-half barrels.

COST OF MANUFACTURE, AUGUST, 1909.

Amount manufactured: 14,600 gallons (292 barrels)

12,600 gallons crude carbolic acid at 12 cents per gal.	$1,512.00
12,300 pounds rosin at $2.48 per hundred	305.04
2,550 pounds caustic soda at $3.70 per hundred	94.35
2 tons coal at $5.00 per ton	10.00
Labor	94.46
Supervision	50.00
Total	$2,065.85
Cost per gallon	14.14

To insure the manufacture of a uniform product, requisitions called for crude carbolic acid of a specific gravity not greater than 0.97, and to contain not less than 15 per cent tar acids. Each consignment of crude carbolic acid received was assayed at the laboratory to determine its specific gravity and percentage of tar acids, for it is necessary to keep the product of a specific gravity approximately that of water, so that it will diffuse rapidly and neither sink to the bottom, nor remain at the surface.

In a hundred square miles of territory treated we used about two hundred barrels of this mixture a month. The cost of manufacture was about seventeen cents a gallon. In the early days we had used various proprietary articles for this purpose, for which we generally had to pay about fifty cents per gallon. Larvacide came in the course of time to be used on the Isthmus for disinfectant purposes of many kinds, and also for the prevention of fly-breeding. We found it most excellent for all rough purposes of this kind, such as disinfecting and deodorizing around privy vaults and similar places.

A sanitary inspector, when malaria is rife, has to be thoroughly familiar with the life history of the mosquito, and particularly with the life history of the anopheles. There are some six or seven hundred species of mosquitoes, and many

of these differ widely in their habits of flight. The stegomyia mosquito is one of the feeblest species in its ability for flight, and it is at once blown away and destroyed when it gets into a breeze. It therefore seldom wanders from the house in which it is bred. The culex solicitans is very strong and bold in flight, and can fly twenty miles in one night before a favoring breeze. This has been demonstrated by Dr. J. B. Smith, of New Jersey. Dr. Smith was the entomologist of the state of New Jersey, and one of the most faithful and successful mosquito workers.

The culex solicitans is the common gray mosquito which breeds so abundantly in the salt-water marshes of our Atlantic coast. The different species of mosquitoes differ widely as to their breeding-places, some species breeding in brackish water, some only in fresh water. Other species breed freely in dirty and muddy water, and still others can apparently live only in fresh, clean water. The two species with which we are most concerned as being disease-carrying mosquitoes are very particular as to their habits, always seeking fresh, clean, clear water in which their larvæ can develop.

The stegomyia likes clean rain water such as is found in cisterns and water barrels. As these collections are found principally around the dwellings of man in towns and cities, this mos-

quito is known as a town mosquito. The larvæ of the anopheles, the malarial mosquito, also likes clear, clean, fresh water, but it requires algæ and grass for its protection. These conditions are best furnished by the edges of ponds and running streams. This mosquito is, therefore, essentially a country mosquito.

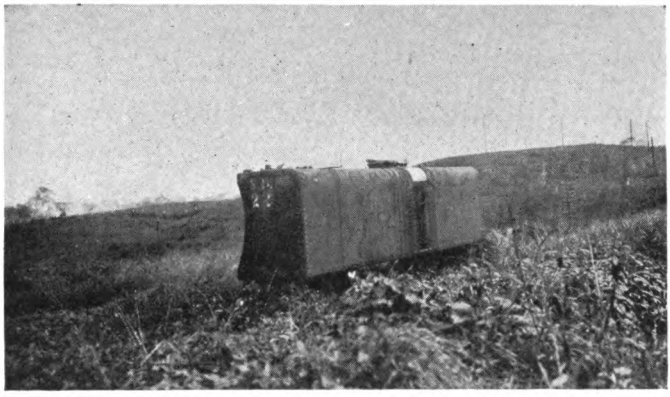
Generally, in any one locality, there are only three or four species of mosquito occurring in any abundance, so that when the inspector has learned to differentiate these, he is pretty well educated for work in that particular locality. Each species usually has some prominent trait; the anopheles, for instance, has the hind legs very much longer than the fore legs, which gives her when at rest the appearance of standing on her head. The stegomyia has prominent white markings on its body and white bands around the joints of its legs, and while these cannot readily be distinguished by the naked eye, they give it a gray appearance which easily distinguishes it from other species in such a locality as Panama.

The culex solicitans and stegomyia look very much alike to the naked eye, so much so that one of our most experienced inspectors at Panama, on returning from a vacation spent on Long Island, told me that the stegomyia was the common mosquito on Long Island. As a matter of fact, the stegomyia never appears farther north than

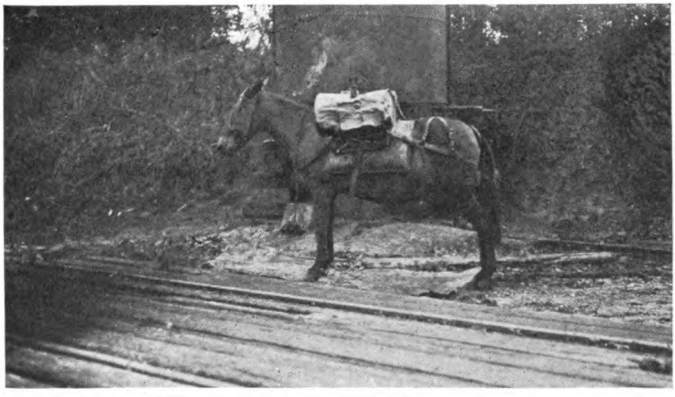
Norfolk, Virginia, unless as a matter of accidental introduction during warm summer weather.

As the inspector deals with the mosquito in the larval stage principally, he must be familiar with the habits of the larvæ, and the habits of the different larvæ differ about as much as the habits of the adult mosquitoes. They also differ much in size and shape; for instance, the larvæ of the anopheles can readily be recognized by the way it comes to the surface to breathe. During this process it lies horizontal to and in contact with the surface of the water. The culex larvæ, when breathing, lies with its tail up and head down. The anopheles is a long, very slender larva; the culex, short and chunky. The anopheles larva is most noticeable from its superior intelligence. It will dive and seek shelter in the grass at any sound or shadow thrown upon the water; the culex larva is sluggish and pays little attention to such things.

The inspector must become very familiar with the half-dozen most frequently occurring larvæ in his district; he must recognize them easily when he sees them, and must know the kind of locality in which to seek for them. He must learn the peculiarity of ditching as applied to drainage intended to prevent mosquito breeding. This is quite an art in itself. Take, for instance, an ordinary depression between two small hills; if we



Old French Engine Tender Used as Storage Tank for Oil.



Mule for Packing Oil to Oilers.

want merely to get the water away for ordinary drainage purposes, a ditch through the center will accomplish this, but sometimes where the water is oozing through the surface on the hillside, you still have soft moist places on each side of your ditch which makes most excellent breeding-places for mosquitoes.

Mr. Le Prince discovered that for mosquito work ditches would have to be run along the hillside to cut off the water from this soft ground and to catch it when it came to the surface. Where the ordinary engineer does ditching, such a detail as this is overlooked by him.

Wherever possible, I insisted upon the sanitary inspector who was instructed in these matters doing his own work, using men employed directly by himself and under his orders and supervision. I think it is of the utmost importance in mosquito work that the health officer should have direct control of the men doing this work. The ordinary engineer has no special knowledge of the life history of the mosquito, and as the ditching and brush-cutting are done to prevent mosquito-breeding, it is not surprising that it is not successfully done by a man who has no knowledge of the mosquito.

All the work at Havana was done by men trained and instructed as to the life habits of the mosquito, and the same was the case for the first

three years at Panama, when the effective mosquito work was done. Whenever speaking or writing on this subject I have insisted upon the necessity of having the execution of the work in the hands of men who have been trained in anti-malarial procedure.

Another duty of the inspector was to see that the houses were properly screened, and that the screens were kept in effective condition. The Commission had several thousand buildings scattered in thirty or more towns, and it endeavored to keep all these buildings mosquito-proof with wire netting. Mr. Wright, the architect of the Commission, developed several very useful types of houses, well adapted to a tropical country and for the use of wire netting. The general plan was not to attempt to screen the doors and windows; such screening is more or less imperfect, and with several entrances to a house, it is impossible with any ordinary care to prevent the doors being left open. Mr. Wright therefore planned his houses so that they were screened in, having only one door of entrance. A house screened in this way is very thoroughly protected against the mosquito. The housekeeper, with very little attention, can keep closed the one screen door that gives entrance to the house.

Another great advantage of such screening is that there is very little interference with the cir-

culation of the air. We used a wire netting of sixteen strands to the inch. In the case of a window screened with such wire, a large part of the air that would ordinarily enter is kept out, and the interior of the house is made hot and uncomfortable in a warm climate. With the whole side of the veranda screened the amount of air kept out is not appreciable, and at Panama there was no complaint that the screening interfered with the ventilation.

Another very great advantage of this style of building was that the galleries could be used as living- and sleeping-rooms, and this at Panama was very generally the case. It was found that the cost of screening the gallery was very little more than that of screening the doors and windows. While screening the whole gallery required much more wire netting, the work itself was very simple. Making the window and door frames brought up the cost of screening them to about the cost of screening the galleries.

Care must be taken as to the quality of the wire netting. We were put to a great deal of expense at Panama by sometimes getting wire netting that would last only two or three months. We finally adopted a specification requiring that our netting should be at least ninety per cent copper, allowing not more than ten per cent of non-corrosive metals. All netting was carefully tested

to see that it came within these specifications. It was the very general opinion on the Isthmus that houses thus screened protected us much more thoroughly from insect life than is the case in most parts of the United States during the summer months. The dwellers in these houses habitually sat on the galleries, with electric lights burning, and would read for a whole evening without being disturbed by any kind of insect.

The inspector had a man constantly employed patching holes and looking after the condition of this wire screening. In our barracks, in which forty or fifty Jamaican negroes lived, it was much more difficult to keep the wire netting in repair, and to keep the screened door of entrance closed, and some mosquitoes would always get in, if there were any mosquitoes around. In many of our stations we succeeded in entirely eliminating the mosquito, as in the district of Ancon. In such districts it made little difference as to the condition of the wire netting; in other districts where the anti-malarial work had been curtailed, mosquitoes were troublesome, and every day some would get into such barracks as I have described.

For these cases Mr. Le Prince and his assistants developed a very effective method. They took an ordinary test tube, put at the bottom of it a few pieces of ordinary rubber, dropped on

this rubber a few drops of chloroform and placed a small layer of absorbent cotton over it to keep it in place. When the mouth of this test tube is placed over the mosquito, she in a few seconds becomes narcotized by the chloroform and dies.

This method of killing infected mosquitoes was developed by Mr. Le Prince and his sanitary inspectors into one of our most effective anti-malarial measures. It can be used where none of the other anti-malarial measures is possible.

For instance, at one time we had railroad construction going on near Diablo Hill. This hill is surrounded by fresh-water swamps on three sides. We put a force of several hundred men to work on this. They were fairly comfortably housed in ordinary box cars, the doors and windows of which had been carefully screened with wire netting. These cars were located at the foot of Diablo Hill, on the edge of the swamp. No anti-malarial work having been done here up to this time, anopheles were very numerous. The swamp was so extensive that efficient anti-malarial work was not considered then practicable. Prophylactic quinin in five-grain doses was being taken by these men, but we knew from a recent experience in this same locality that infection was so severe that prophylactic quinin alone would not protect our men. We knew, also, that a certain number of mosquitoes would get by the

screens every night. With a number of men living in a car and using one door, we knew that on the average that door would be open a large portion of the time. From inspections, we had found that there were always a considerable number of mosquitoes in the cars. Mr. Le Prince reasoned that while the mosquito-catcher could not by any possibility catch all the mosquitoes in every car every day, he would catch most of them. It was therefore extremely improbable that any individual mosquito would escape the mosquito-catcher for ten successive days. As it takes ten days from the time at which the female anopheles mosquito bites the man sick with malaria until she herself becomes able to transmit the disease, no mosquito would live long enough under these conditions to become disease-bearing. And in practice this proved to be the case. The mosquito-catcher went through the cars every day and caught all the mosquitoes he could find, and continued this day after day as long as the cars remained in this swamp. The force was kept here for several months without suffering appreciably from malaria.

This was the more impressive from the fact that just before we had our negro employees in cars on the edge of the swamp, we had kept a considerable force of marines for several weeks camped in tents on top of Diablo Hill. These

marines suffered very severely from malarial fever, very few of them escaping. The tents not being screened, we could not carry out the same method of catching infected mosquitoes which was so successful in the case of our negro laborers, a couple of hundred yards distant from this same camp. One of the medical officers reported to me one day that, under a mosquito-bar which he had kept over a sick man during the preceding night, he caught in the morning quite a large number of anopheles—about fifty, as I recall it. We used this method more and more during the later years of our work on the Isthmus.

It is quite feasible everywhere, by proper drainage, to eliminate entirely the anopheles mosquito, and in several of our towns and villages we succeeded in doing this, and could have done it everywhere if it had been thought desirable by the authorities to apply the same methods, which had been successful at these places, and previously at Havana.

At stations where mosquitoes were more or less troublesome, the mosquito-catching method above described was very useful in the barracks of the laborers. In a barrack building which quarters forty or fifty men the best screening will not altogether keep out mosquitoes, if there are many mosquitoes around. Holes will continually be punched in the wire netting, but mosquitoes enter

principally through the constant opening of the door, and through the door being carelessly left open. We found that at such stations we could keep malaria down by catching malarial mosquitoes.

Occasionally, at a station where we had controlled mosquitoes for several years, a great swarm would appear for reasons which we could not explain. These swarms would not remain for a long time, and usually they were not made up of anopheles. While they lasted, we used the method of catching infected mosquitoes for the protection of our force. On one occasion, however, we had a large flight of anopheles. They swarmed everywhere about the station, and we could not account for them, or discover where they came from. The sanitary inspectors' department devoted all its spare force to investigating this point, and for a considerable period Mr. Le Prince devoted all his time to the subject. He finally located the breeding area in a small swamp about a mile from the town. This swamp had existed there during the preceding years when Gatun had been comparatively free from mosquitoes. At this particular time when the anopheles were so troublesome, the engineers had begun to pump silt from the channel of the Canal into this swamp. This silt was carried by salt water, which made the water of the swamp brack-

ish. This brackish water apparently favored the development of the anopheles, and they were produced in enormous numbers. The engineers were requested to pump sea water into the swamp area for a few days. This soon made the water of the swamp too salty for the breeding of the anopheles, and in a few days the mosquitoes disappeared from the town.

It is remarkable that anopheles should have bred in this brackish water, as it is a mosquito which generally seeks fresh water. It is probable that the brackish water made some advantageous change in the food supply of the larvæ, and that when the swamp was filled with pure sea water, this food supply was stopped. This is the longest flight of anopheles which we discovered on the Isthmus.

The method worked out by Mr. Le Prince and his assistants was original with them. They would take a screened cage containing a large number of anopheles mosquitoes, and spray them with a solution of analine blue; take them down at night and release them at the suspected spot. They would erect a tent at some convenient place in the town to be examined, put a mosquito-bar in this tent with a man under it as a bait for the lady anopheles, leave the bar open during the night, closing it early in the morning before the anopheles which had bitten during the night had

an opportunity to escape. The mosquitoes under the bar were caught and carefully examined. If any blue-stained mosquitoes were found, it was proof that they had come from the point at which the stained mosquitoes had been released the evening before.

The job of acting as bait for the mosquitoes during these investigations was a position much sought after by our negro employees. They were paid by the hour the same wages that the day-laborers received. To be paid full wages for sleeping in a comfortable bed struck the Jamaican as being as near complete bliss as was to be found in this world.

Mr. Le Prince did a great deal of work in experimenting upon the flight of the anopheles at other stations, and during his investigations came across many curious things as to the habits and tastes of the anopheles. He found that the anopheles would show a marked preference for a particular horse; though there might be several other horses near and accessible, they would bite this one horse almost exclusively, the taste of whose blood they seemed to prefer. The same thing was true of men. We had one inspector of whom the mosquitoes were excessively fond. When they were not very numerous, they would scarcely trouble his companions at all, devoting all their attention to him. This poor fellow died

as a result of this kind of work. He was Mr. Le Prince's main dependence for investigations of this kind. He did not suffer particularly from malarial fever while on the Isthmus, but a short time after his return to his northern home, he died of an attack of pernicious malarial fever.

These various methods of combating malaria were very successful. In some of the towns, as I have already said, they were just as successful as they had been in the city of Havana, and I myself have no doubt that, if we could have continued the methods which we inaugurated on the Isthmus, we should have been just as successful with malaria at Panama as we had previously been with the disease at Havana, and at no greater cost. As it was, we succeeded in so protecting the force against malaria that it did not interfere to any appreciable degree with its working capacity.

CHAPTER XV

THE WORK AT THE HOSPITALS

DR. JOHN W. ROSS, of the United States Navy, Major Louis A. La Garde, of the Army, and I had all had a large experience in tropical military service. We were, therefore, thoroughly imbued with the idea that from the very beginning we must make ample and liberal provision for the care of a large number of sick. We were impressed with the fact that the constant sick rate of the Army in the Philippines had been ninety per thousand during the year 1898; that it had been even larger with our Army at Santiago, Cuba. We therefore thought that we should prepare to have at least fifty per thousand of our employees on the Isthmus constantly sick.

Our estimates were based upon fifty thousand employees. If, as occurred with our Army in the Philippines, we should have three hundred per thousand constantly sick, we would need a bed capacity, equipment and personnel for the care

of fifteen thousand sick. If, as we hoped, it might not exceed fifty per thousand of our employees sick, we should only need a bed capacity of twenty-five hundred beds. We determined to keep at least fifty beds per thousand for our actual force; that this should be the minimum number, and that the number of beds should be increased as the force increased.

It is a matter of interest to note the fact that during the year that our force was at its maximum, fifty-eight thousand men during the calendar year 1913, we had a hospital capacity of just about twenty-five hundred beds, though the constant sick rate of our employees at this time was only about twenty-two per thousand. The hospital service had become so popular, and had acquired such a reputation for the skillful service and good care which could be obtained there, that a large number of people came to seek its benefits from various Spanish American countries north and south of us.

We had at this time some eight hundred individuals in the hospitals who were not Canal employees. Dr. Ross was determined that our hospital service should be first-class in every respect; that a sick employee of the Canal Commission on the Zone should be able to command just as skillful, and just as good care, as he could command in our largest centers in the United States.

With this object in view the hospitals were equipped with bedding and other hospital supplies of the very best kind. Very little was expended upon buildings. In general we used the buildings that had been erected by the French some twenty years before, and which were still standing in fairly usable condition.

Dr. Ross impressed upon everyone with whom he came in contact that the hospital department was organized primarily for the care of the sick, and that the comfort and happiness of the sick must always have the first consideration. This department retained this principle as its most marked characteristic during the whole period of its existence.

The very best equipment in all directions was obtained, and the very best class of young physicians and surgeons was secured from the United States. At our maximum we had, all told, one hundred and two physicians in the Sanitary Department. Our nursing force was as enthusiastic, as good and as efficient as could be found anywhere. At our maximum we had one hundred and thirty trained nurses from the best training-schools in the United States.

As I have mentioned before, the Canal extended from northwest to southeast some fifty miles, the city of Colon being at the northern end and Panama at the southern. The working force was

scattered, more or less, along this line between these two points.

The French had left two large hospitals, Ancon Hospital at Panama on the southern end, and Colon Hospital at Colon on the northern end. We determined to utilize these two hospitals as base hospitals, and to bring as many patients as possible from along the line to these institutions. We divided the territory between Panama and Colon into as many medical districts as we had sanitary districts, and in each of these districts a small hospital was erected, from twenty to one hundred beds in size, where a certain number of sick could be treated, whom we thought it would not be advantageous to transport to the two base hospitals.

Many of the districts had several villages within their borders where the laborers lived. Each of these villages had in it a small hospital of from five to fifteen beds where the sick were kept until they could be moved to the district hospital. We had some forty of these sub-district hospitals, which were generally known as rest camps. This gave us, all told, some sixty hospitals.

It was evident that we could not afford to make all these sixty hospitals first-class hospitals, and we therefore decided to concentrate upon our two base hospitals and make them first-class in every respect. For instance, in the surgical line we de-

termined to have all the instruments, equipment and personnel that could be obtained in the best equipped hospitals in our large cities. The eighteen district hospitals were well equipped to care for emergency patients, both medical and surgical, and for such as it was thought would be injured by being moved to the base hospitals. The sub-district hospitals, or rest camps, were not equipped at all for the care of surgical cases, but merely for the care of medical cases until they could be moved to the district hospitals.

The sub-district hospitals were used a great deal for the care of men who were sick only for a day or two. It was believed that there would be a certain amount of injury done in transporting the wounded by train. Some of the stations were twenty-five miles from either Ancon or Colon, but at the same time it was thought that the better care, skill and attention that the patient could get in the large and well-equipped hospitals, such as Ancon and Colon, would a great deal more than counterbalance the injury done by the long railway haul.

For the purpose of transporting the sick and wounded from the various district hospitals to the base hospitals, hospital cars were run over the road morning and evening, in both directions. The hospital cars were of local manufacture, gotten up by Dr. Carter, the then director of hos-

pitals. He took the ordinary baggage car, rigged up iron frames over which canvas was stretched, and these frames were secured to the walls with hinges, so that when not in use they could be folded down on the side of the car, out of the way. There were sixteen of these beds in each car. The car was also arranged so that when the beds were not left down there was a row of seats available all around the car. Ordinarily, in transportation there would be five or six stretcher cases occupying beds in the car, but the large majority of the cases would be sitting up. Each car was provided with a toilet, a small supply of medicines and surgical dressings, and two small closets in which such things were stored. The car was manned by a trained white male nurse and a negro assistant. The car was screened.

The trains at Ancon and Colon were met by the necessary number of ambulances, and the patient in this way was carried to the hospital. Cases of pressing emergency were brought on special trains. The district physician could generally get a special train if he certified that there was necessity for it.

This method of transportation for the sick proved eminently satisfactory, and during our ten years of construction work on the Isthmus, it fulfilled every need. We transported a great many thousand patients in this way without a mishap

of any kind due to the method of transportation.

The country along the Canal route was exceedingly rugged, and many of the district hospitals, for the first few years, were inaccessible to wheeled vehicles. So the patients who could not walk had to be carried to the hospital car on stretchers. But long before the period of construction was half through roads had been built to all these district hospitals.

In charge of the medical matters in each of our twenty districts was a district physician. This physician had charge of the district hospital, and looked after the patients there. It was also his duty to look after the families of employees. No charge was made for the medical care of an employee, or for medicine furnished him, or for surgical operations performed upon him.

The district physician had the authority to send any employee he thought best to the hospital. If the employee preferred to stay at home for treatment he was charged one dollar for each visit of the physician. These fees reverted to the Commission. The physician was paid a fixed salary by the Commission, and was not allowed to make any charge for his services. Members of families of employees were charged one dollar a day for hospital care, and could be admitted on the order of the district physician. Families of employees who received less than fifty dollars a month were

charged only thirty cents per day for hospital treatment. As a rule, both employees and their families preferred to come into the hospital when sick, rather than to be treated at home. The class of employees receiving less than fifty dollars a month was almost exclusively Jamaican negroes. During the earlier years of our Isthmian work the negroes were afraid of the hospitals and did not like to come in. This applied particularly to the women and children. But as years went by we gained their confidence entirely, and during the last years of construction, the hospital accommodation for negro women and children was always full, though we were constantly extending this branch of our hospital.

In each district one or more dispensaries were maintained. In immediate charge of the dispensary was a competent druggist who had one or more men under him for assisting him about the dispensary. The district physician presided over the dispensary and advised without charge anyone who applied for treatment, and furnished him with medicines if he were unable to pay. Quinin was given at the dispensary to anyone who applied. In some of the larger districts where the population amounted to eight or ten thousand, the district physician had as many as four assistants. All the doctors on the Isthmus had to be graduates of medical schools in good standing, and, except for

the first few years, of construction, had to pass a civil service examination.

There was a very great sanitary advantage in our giving in this way to the whole population free medical service and medicines. It kept the district physician accurately informed of what character of sickness was occurring in his district. The sanitary authorities thus had the very earliest information with regard to such diseases as yellow fever and plague, and they were enabled to take the proper sanitary precautions at the time when they would be most efficacious. Many times information obtained in this way enabled us to stamp out these diseases in their incipiency and before they could get started as epidemics.

The district physician also had inspectorial control of all buildings within his district. He was directed to pay particular attention to hotels, eating-houses, etc. He was required to make a monthly report on these subjects. Faults reported by the district physician were carefully looked after by the central sanitary office, and were usually promptly corrected by the responsible sanitary official.

The sanitary inspector had the care of all the cemeteries in the Zone, which were twenty-odd in number. Each of the districts had a cemetery, and no burials were allowed except in these cemeteries. The inspector kept a register of all

burials, and any death which was at all suspicious was investigated by the authorities of the Sanitary Department. The charge for preparing the grave was just about enough to cover the expense of digging. The control of the cemeteries by the Sanitary Department we considered very important from a sanitary point of view, as in this way we could keep an absolute register of all deaths occurring, and no death from a contagious or infectious disease could occur without the authorities being informed.

On Flemenco Island was located one of our oldest cemeteries, though small in size. Here were buried quite a number of our naval officers and sailors who had died of yellow fever on our war vessels while in the bay of Panama during the preceding fifty years. Here were buried, also, patients who died at the nearby quarantine station. The site was beautifully located about half-way up Flemenco Hill, in a dense tropical forest, with just below it, at the water line, the vine-covered ruins of an old Spanish fort. At the present time the top of Flemenco Hill has been cut away for the location of one of our batteries. The old fort has been razed for the location of another battery and the tombs and monuments of the old cemetery have been moved to the grounds of Ancon Hospital.

In the grounds of this hospital was located the

cemetery where most of the employees and laborers who had died during the period of construction were buried. This also was a very picturesque place, situated on the side of Ancon mountain, looking to the north, with Culebra Cut instinctively in view. The grounds were prettily laid out and artistically planted with tropical trees and shrubbery. Here we had some two thousand interments.

But the principal cemetery was that located at Mount Hope. This was the cemetery for the city of Colon, and in all the writings of the early days on the Isthmus, it is known as "Monkey Hill." It has been in use ever since the foundation of Colon, about 1850, and contains a large number of interments. Here sleep most of the men who died during the construction of the Panama Railroad, and many others well known on the Isthmus during the fifty years of the existence of the railroad as a transcontinental route. Dr. Connor, health officer of Colon, gave a great deal of attention and thought to the beautifying of this piece of ground, and it is now as pretty a garden of tropical trees and shrubbery as can be seen anywhere.

At Porto Bello we used the principal fort on the north side of the harbor as a cemetery. This structure, though built of brick some two hundred years before, was in a very good state of preservation. The mountain rose several hundred feet on

this side of the harbor, and on the side of this mountain, to the seaward from the old fort, was located our great Porto Bello quarry, from which was obtained the stone for building the Gatun locks and the Colon breakwaters. The fort was a very strong and complete military structure for its time, and it was located at the foot of the mountain, near the water's edge. When I first visited the ruin, it was completely covered with jungle, to such an extent that it could not be entered or recognized as a structure built by human hands. I reached it and made an entrance by having a native machete-man cut out the jungle enough for me to force my way through behind him. Large trees were growing in all parts of the old structure, some of them six or eight feet in diameter, and more than one hundred feet in height.

The interior of the fort was cleared of jungle and arranged so that it could be used as a cemetery, and here are buried the employees who died at Porto Bello within the six or seven years during which we operated the quarry. I selected it as the cemetery site, because it struck me as being appropriate that this old fort, which had seen so much of war, should finally be used for so peaceful a purpose as the last resting-place of the laborers engaged in the construction of a commercial enterprise like the Panama Canal, for which so much is hoped for the benefit of the whole

human race. The old fort had been built by one set of pirates, the old Spaniards, to protect the plunder which they had wrung from the Incas and other natives of America, from that other set of pirates who infested the Spanish main, and were constantly attempting to wrest from the Spaniards this plunder.

CHAPTER XVI

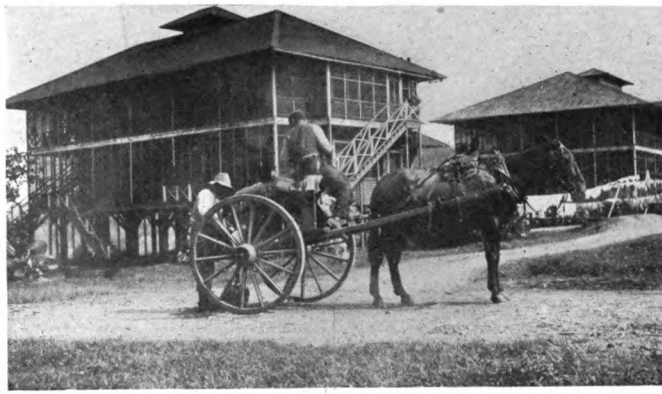
MALARIA WORK AND THE HOSPITAL SYSTEM

IN the early years of our construction malaria was very common and gave a great deal of trouble. As I have explained before, malaria is caused by a small animal parasite which lives in the blood of man and feeds upon the red globules. The excretions of this parasite poison man and cause the fever and other symptoms which we know as malarial fever. This parasite is transferred from the sick man to the well man by the bite of the mosquito. Now it is quite evident that if in any way we can kill the parasites as they exist in man, we not only cure the individual man of malarial fever, but at the same time prevent his being a means of infection for other men who have not yet acquired the disease. In a purely empirical manner, some one hundred and fifty years ago a drug was discovered which man could take without injury to himself, and which, when absorbed into the circulating blood was deadly to the malarial

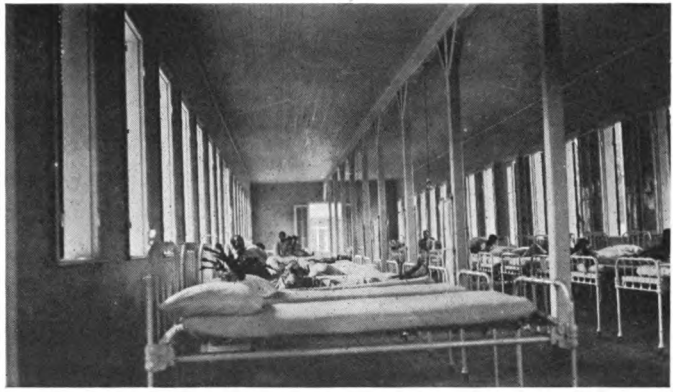
parasite there swimming about. It is somewhat singular that this drug should have been discovered not very far from Panama. A Peruvian Catholic priest found that the Indians in certain parts of Peru cured themselves of the fevers native to that country by the use of the bark of a certain forest tree common to that region. Its benefits were so evident that the wife of the Captain-General of Peru became interested in the matter, and spread about a knowledge of the virtue of this wonderful bark, and introduced it into the mother country and other parts of Europe. This lady was the Marchioness of Cinchona. No drug ever discovered has been as useful to mankind as quinin, and it remains up to the present time one of the few specifics known to the medical profession.

Besides curing the malarial patient after he had gotten the parasite into his blood, it was the desire of the Sanitary Department to have the blood of all persons on the Isthmus in such condition that it would not harbor the parasite. We believed that if everybody would take five grains of quinin a day, this quinin would be absorbed into the blood and render the blood so poisonous to the malarial parasite that when the parasite was injected into the blood by the mosquito it could not thrive and develop, but would die.

With the object of getting as many people as



Distilled Water Cart. Culebra.



Ward at Ancon Hospital.

possible to take [illegible] physician had attacked [illegible] quinin dispensers. The [illegible] man furnished with quinin [illegible] spent the day going [illegible] offering them quinin. [illegible] district physician [illegible] offered quinin. [illegible] what was known as [illegible] This was a quinin [illegible] ounce should contain [illegible] ingredients were added [illegible] in smell, taste and appearance. [illegible] penser also carried [illegible] and tablets and [illegible] and eating-houses. [illegible] were fed quinin [illegible] placed on the [illegible] messes, and an [illegible] ously posted among the [illegible] of teaching them [illegible] quinin in this way. [illegible] force anyone to take the prophylactic quinin, but explanation and persuasion were used to their fullest extent.

By these methods we succeeded when the use of quinin was at its maximum in getting our force to take about forty thousand doses per day. The

possible to take quinin every day, each district physician had attached to his staff one or more quinin dispensers. This quinin dispenser was a man furnished with quinin in various forms, who spent the day going about among the laborers offering them quinin. It was the endeavor of the district physician to have each laborer once a day offered quinin. The dispenser carried with him what was known on the Isthmus as quinin tonic. This was a quinin solution made up so that each ounce should contain five grains of quinin. Other ingredients were added so as to make it attractive in smell, taste and appearance. The quinin dispenser also carried with him quinin pills, capsules and tablets, and the patient was allowed his choice.

The Commission ran a large number of hotels and eating-houses, where all classes of employees were fed. Quinin tonic and quinin tablets were placed on the tables of all these eating-houses and messes, and an educational campaign was vigorously pushed among the employees, with the idea of teaching them what was aimed at by taking quinin in this way. No attempt was ever made to force anyone to take this prophylactic quinin, but explanation and persuasion were used to their fullest extent.

By these methods we succeeded, when the use of quinin was at its maximum, in getting our force to take about forty thousand doses per day. The

men responded very heartily and loyally to this system of education. I was very much gratified at the results, and feel confident that no system of compulsion could have been as successful. I am satisfied that during the early years of construction, before our other anti-malarial work had produced results, this giving of prophylactic quinin on so large a scale was of the very greatest use to us.

Under some circumstances we required our employees to take quinin. At Taboga, down in Panama Bay, we had a convalescent hospital where the men were sent to spend a week or two when convalescing from the severer forms of malarial fever. A man with malarial parasites in his blood was a source of infection and of danger to his well companions. With the idea of being certain to kill all the parasites in his blood, he was required to continue large doses of quinin for a week or ten days after the stoppage of his fever. But such is the nature of man that as soon as you begin to force him to do a thing, from that moment he begins to seek ways by which he can avoid doing the thing you are trying to force upon him.

A certain number of men, when they were given their daily dose of quinin in the dispensary, would manage to throw their tablets out of the dispensary window. The old turkey-gobbler that was the pet of the hospital seemed to like the stimu-

lating effect of the quinin and gobbled up all the tablets he could find. He became so dissipated in this way that he finally developed quinin amblyopia. This amblyopia is a species of blindness that is sometimes caused by too much quinin. The doctor finally had to confine his old gobbler and keep him away from quinin tablets until he recovered his sight. I cannot vouch for this story, but I was often twitted with it as an illustration of how the men were treating prophylactic quinin. Even if this story were true, it could not be used as an argument against prophylactic quinin on the Isthmus. In general, no attempt was made at compulsion, and there would therefore be no object in a man taking quinin and throwing it away.

I have noted before that our hospital system was planned upon the scheme of some forty sub-district hospitals, or rest camps, which fed about twenty district hospitals. These twenty district hospitals, by means of hospital trains, fed two base hospitals, situated respectively at the northern and southern end of the Canal, Colon and Panama. The one at the southern end was much our largest hospital, containing at its maximum about fifteen hundred beds.

The city of Panama is situated on a peninsula, stretching into the bay of Panama. Just north of the city rises Ancon mountain, some six hundred and fifty feet in height. This mountain is

only accessible to a pedestrian; the trail is too rough and precipitous for horse or mule. The northern suburb of the city of Panama is known as Ancon, and this village nestles about the southern foot of Ancon mountain. The line dividing United States territory from Panama passes between Ancon and the city of Panama. Ancon is therefore under the jurisdiction of the United States.

Ancon Hospital is beautifully located along the southern and eastern front of Ancon mountain. The French early in their construction period, about 1882, commenced building their main hospital there. The side of the mountain was graded for roads and laid off in the most beautiful and picturesque manner. Every variety of tropical shrub and plant was introduced from other parts of the tropical world and planted around the grounds. Every opportunity for picturesque location of buildings was seized, and over thirty hospital buildings of various kinds were located over a large area, extending along the northern and eastern sides of Ancon mountain.

The maximum bed capacity under the French was about seven hundred beds. The hospital built by them was well manned and equipped, and was a very much better institution than any hospital in America that I know of at the same period carried on by a firm or corporation. The French did

most of their work by contract so that almost all of their patients were employees of the various contractors. Each contractor was made responsible for sick employees whom he sent to the hospital, and was charged one dollar a day for each sick employee as long as he remained in the hospital. A dollar a day was a very moderate charge for the care and attention given a sick man in Ancon Hospital, and I know that the charge did not cover the cost to the old company.

It is the general belief among the people on the Isthmus, who were there during the general construction work of the old French Company, that a very small portion of the employees of the contractors came into the hospital. Notable among these is Sir Claude Mallet, who was the English representative in the city of Panama during the period referred to, and who is at present the British minister to the Panaman Government. From my knowledge of human nature I feel sure that the French contractors did not send a large proportion of their sick to Ancon Hospital. I am surprised that under these circumstances the hospital ever contained seven hundred patients. If we had been doing the work and had twenty-five or thirty American contractors employing sixteen or seventeen thousand men, I should be very much surprised if we at any time had seven hundred patients in the hospital, if the contractors were re-

quired to pay one dollar per day for each of the seven hundred patients.

Attached to the hospital the French had a dairy with a very complete set of dairy buildings. In connection with this dairy was a farm of some three or four hundred acres. The water supply for the hospital during the French occupation came from three or four beautiful springs which issued from the side of Ancon mountain. Night soil was taken care of by a bucket system of closets.

The hospital system, on account of the topography, was necessarily the pavilion system. This system was probably the best that could be adopted for both the local and climatic conditions. The cooking was done at one central kitchen, and the cooked food distributed to the wards, where it was consumed.

The nursing force was composed of Catholic Sisters, assisted by negro maids and orderlies. These orderlies and maids did the manual work and rough nursing, under the supervision of the Sisters.

The medical staff consisted of a sufficient number of French physicians. The superintendent during most of the period of construction of the old company and up to the time that we took charge in 1904 was Dr. La Crosade. He remained with us for several years, and did for us most valuable and useful work.

The hospital was not popular among the French employees. The mortality there was very high, and it was soon recognized that men contracted yellow fever there; for instance, a man, otherwise well, would break his leg, be sent to the hospital, in the course of four or five days develop yellow fever, and within ten days be dead. This fear of the hospital was another reason why French employees did not go there. Most of the whites and the better class of French employees, when they were taken sick, remained in their boarding-houses and homes in the city of Panama.

In making these remarks I do not intend to reflect in any way upon the management of Ancon Hospital by the French. If we had had this hospital in 1884 we should probably have obtained no better results than they did. At that time they did not know that the mosquito transmitted yellow fever from man to man, nor did we know it then. Still, the hospital records show that in the nine years of construction under the old French Company, twelve hundred patients died in Ancon Hospital from yellow fever. These were mostly Frenchmen, and they died in the building used for white employees, the Saint Charles. This building was occupied for the first few years of our construction of the Canal by Dr. Carter and myself, with our families. The fact that we were willing to place our families in such a building,

located in one of the worst yellow-fever centers, shows how thoroughly we believed that yellow fever was not infectious in the ordinary sense of the term.

This building was about the center of the hospital grounds, and occupied a most attractive site. It was situated about two hundred feet up the side of the mountain looking to the northeast. A macadam road skirted the building on the down side, and the masonry retaining-wall supported this road on the lower side. Between the border of the road and the retaining-wall was a superb row of stately royal palms. Behind the building rose the mountain for four hundred feet, covered by a perfectly impenetrable tropical forest, giving to the picture the deepest possible dark green background. The view to the north and east extended for miles and miles. To the east, over the bay of Panama, dotted with its forest-clad islands, I have many times watched from the gallery of this building that anomaly, so generally remarked at Panama, the sun rising out of the Pacific.

To the north and east were in view the various ranges of Andean Mountains which make up the backbone of the Isthmus. From this point, four or five ranges of mountains could be seen, and in the evening, when the sun was setting behind the Ancon mountain at one's back, the play of colors

was superb: light green upon the nearer ranges, changing into deep azure upon the farther ranges, with the mountain tops and higher valleys covered here and there with a robe of white mist.

For the fourteen years after the failure of the old French Company in 1889, Ancon Hospital had financially a most straightened time, and the Sisters who were in charge had to reach out in all directions to make both ends meet. They deserve a great deal of credit for the brave and successful struggle which they made in supplying the wants of the sick intrusted to them.

Major La Garde, of the United States Army, was appointed Superintendent of Ancon Hospital, and took charge in June, 1904. He rapidly and successfully proceeded to organize the hospital on such a basis that it was always able to care properly for all patients who presented themselves.

For the first year there were almost insuperable difficulties in the way of getting supplies of all kinds, but gradually these troubles were corrected. We used all the old French buildings in much the same manner as had the French. As the number of patients increased, the old French buildings were enlarged, generally by adding a second story, and a few new buildings were added, until finally the capacity of the hospital had risen to fifteen hundred beds.

Into all these buildings a piped water supply

was introduced, and the bucket system for night soil was everywhere replaced by modern flush closets. Bathing facilities were also supplied wherever needed. A good sewage system connected all these buildings with the sewers of the city of Panama. The old lighting system of candles and lamps were replaced by electric lights. All the buildings were thoroughly screened with wire netting. This precaution was almost essential in the early years before we got mosquito-breeding as thoroughly under control as it later became.

In 1904 and 1905 we treated a good deal of yellow fever in this hospital, and in the wards where we treated yellow fever we had to be particularly careful. Most of the patients in these wards were non-immunes, that is, were patients who had not had yellow fever. The nurses and doctors were also generally non-immunes, who were liable to yellow fever. We had, therefore, to be absolutely certain that no mosquito which could carry yellow fever from patient to patient, or to the doctors and nurses, got into these wards.

The screening was very carefully done under the supervision of Mr. Le Prince, who formerly had charge of similar work at Havana. Only one entrance was used for each ward, and this entrance was closed by a screened vestibule, with double doors. A watchman was always on duty in this

vestibule, whose business it was to see that any person entering the vestibule from the outer door, closed the outer door before opening the inner. Notwithstanding the large number of cases of yellow fever treated in the yellow-fever wards of Ancon Hospital in the years 1904 and 1905, and in spite of the fact that in these wards were a considerable number of non-immune patients who did not have yellow fever, and the further fact that most of the doctors and nurses were non-immunes, not a single case of yellow fever developed in Ancon Hospital during American control of that institution. I wish to except from this statement one of the female nurses. This nurse did have a very severe case, and came very near dying. The evidence seemed very strong that she had not contracted the disease in the hospital. She was in the habit of going down frequently into the city of Panama in the evening after sunset where infection was very rife. Soon after her recovery she married one of the young doctors connected with the hospital upon whom public opinion settled the blame for her contracting the disease, because he had so frequently inveigled her into taking trips into town.

That no case of yellow-fever infection occurred in the hospital is the greatest possible compliment to the efficiency of the system established by the authorities for its prevention. It made a very

strong impression both upon the Americans and Panamans. All could see that we had done something that had radically changed conditions as they had existed before in Ancon Hospital. Formerly, nearly every white non-immune who was taken to the hospital developed yellow fever. Now, they could see that the yellow-fever wards of Ancon Hospital were safer for a non-immune than was any part of the city of Panama. When it was explained to them that there was no mystery about this; that it had been discovered that yellow fever could not be conveyed from man to man except by the stegomyia mosquito, they were prepared to accept this as the proper explanation.

Probably, if the French had been trying to propagate yellow fever, they could not have provided conditions better adapted for this purpose than the conditions which they did establish with an entirely different object. The stegomyia were bred everywhere about the Ancon Hospital grounds in the usual numbers found in almost every tropical community, due to old cans, bottles, rain-water barrels, roof gutters, etc. As I have mentioned before, the grounds were most beautifully laid off and every kind of tropical bush and shrub carefully fostered in the various plots about the grounds. There is down there a large ant, known as the umbrella ant, that is very destructive to most shrubs and plants. A colony of these

ants will, in the course of a single night, cut every leaf from a good-sized orange tree. The leaf is cut into a piece about half an inch in diameter and carried off by the ant in his nippers, and when you see a column of these ants crossing the path, hundreds and thousands of them, with these circular pieces of leaves in their nippers, it looks very much as if they were carrying them for protection against the sun. Hence their name, "umbrella ant."

Now, in order to raise any vegetation at Ancon, the plant has to be protected from these ants. The French used for this purpose a pottery ring. The ring was filled with water and the plant was placed in the large hole in the center. This thoroughly protected the plant, as the ant was unable to cross the water. But the water in the ring was an ideal breeding-place for the stegomyia mosquito, and as there were several thousand of these earthenware rings about the grounds, close to the wards, a more perfect arrangement for the propagation of yellow fever could not have been adopted, if the authorities had this object in view.

Knowing that shrubbery protected and harbored mosquitoes, we cleared off, as was our rule, everything within two hundred yards of any of the buildings. It looked very much like vandalism on our part to see all the beautiful plants, rose bushes, flowers, etc., which had been for so

many years carefully nurtured and cared for by our French predecessors, ruthlessly destroyed.

But our work was successful, and in the course of time we got rid of mosquitoes entirely in the grounds of Ancon Hospital. We continued to keep the buildings well screened, however, though I feel sure that we could now treat cases of yellow fever in Ancon Hospital in unscreened wards and still not have the disease transmitted to the non-immunes in the ward, for the reason that there are no stegomyia there to transmit the disease. This statement is not altogether theory on my part.

On the next hill, about a quarter of a mile from the old yellow-fever wards of Ancon Hospital, is the Tivoli Hotel. This hotel is owned and operated by the Canal Commission, and for the last few years has been filled with visitors from abroad, principally from the United States, who were of course entirely unacclimated. During the months of the dry season the hotel is crowded, and for the last two years it has been kept full nearly all the year round. During these last two years about thirty thousand sight-seers have visited the Isthmus.

This hotel is practically unscreened. While the doors and windows are provided with screens, such screening, where there are many doors and windows, is so imperfect that in the tropics it gives little protection against yellow fever and malaria.

Stoned Ditch near Tivoli Hotel. Ancon, Panama.

Bad Anopheles Breeding-ground on Artificial Fill. La Boca.

No attempt at all was made to screen the galleries of this hotel. Hundreds of visitors spent the whole evening on these galleries until twelve and one o'clock at night, yet we had no cases of yellow fever or malaria developing from such exposure. If this had occurred ten years before and three hundred of these unacclimated visitors from the United States had sat for an hour or two after sunset on this gallery, exposed to the deadly night air, it would probably have meant that every single one of them would have contracted fever, and a considerable number of them would have died. The only difference between now and then is that we have drained and cleaned the country around this hotel, so that now there are no pools or puddles, or places of any kind within two hundred yards of the hotel where mosquitoes can breed, and consequently there are no mosquitoes.

The fact that unacclimated non-immunes can live in the Tivoli Hotel without contracting fever is evidence that we could do without screening in our wards at the hospital, but we thought it unwise to do away with the wire netting there. We thought it equally unwise not to screen the Tivoli Hotel, but the expense was large, and the architect thought it would mar the appearance of the building, so it was left off by the authorities, in spite of my advice on the subject. The first guests in the Tivoli Hotel were President Roosevelt and his

party, who were there in November, 1906. I succeeded in getting the authorities to screen thoroughly the portion of the building occupied by the President.

As time went on and we found that we had freed the hospital grounds from mosquitoes, we began to replace the flowers and shrubbery which we had swept away in the early sanitary work. But we realized that we had to protect all vegetation from the ants; if we did not, it would be at once destroyed. While the methods used by the French for this purpose had been entirely successful and efficient as far as protection from ants was concerned, we could not use it on account of its mosquito-breeding qualities.

The umbrella ant, in leaving its nest on its foraging expeditions, makes a very distinct trail some four or five inches wide between its nest and the tree to be attacked. Next morning, by following the trail, you can easily find the nest. Colonel Phillips, the superintendent of the hospital, found that by pouring a little bisulphid of carbon into the ant-hole, allowing it to vaporize for a few minutes and then exploding it, the gas would penetrate into every part of the nest and kill all the ants. In this way, all the umbrella ants around Ancon Hospital were killed off. At first it was very laborious, and took the entire time of one man, but in the course of time all the nests in the

neighborhood were destroyed, and it is now only at long intervals that a new colony comes in and has to be killed off.

At the present time the grounds are even more filled with shrubbery and flowers and tropical plants generally, than they were under the French, and they present as beautiful and attractive an appearance as can be found anywhere in the tropics. Entomologists tell us that this ant does not collect the leaf for food, but chews it up into a pasty mass, places it in the storehouses of its nest, and grows upon it a fungus which he uses for food.

The food for this large hospital of over two thousand people was cooked in a large and airy kitchen, situated about the center of the grounds. This kitchen was equipped with every modern convenience both for good and economical cooking. Cooking by steam was used in part, and cooking on the range, for such things as were best prepared in that way. The food when prepared was sent to the various wards, the receptacles being carried in hand carts.

The wards were so arranged that every two of them had a dining-room and diet kitchen in common. In each diet kitchen the heating apparatus was so arranged that the food brought from the center kitchen could be re-heated before being used.

On a spur of the mountain near the center of

the grounds was located the operating-room, with seven or eight surgical wards grouped around. This operating-room was erected by the French about the year 1882. We repaired the building and enlarged it somewhat. Dr. A. Herrick, the chief surgeon, equipped this building with every modern surgical appliance, such as x-ray machine, etc., etc. The results of the surgery at Ancon compare favorably with the results obtained anywhere else.

A medical clinic was built up under the supervision of Dr. W. W. Deeks, where every variety of tropical disease could be seen in all its phases.

A laboratory for original research was also attached to the hospital. This laboratory was developed by Dr. Samuel Darling, and in it a great deal of useful original work has been done. The pathological work of the hospital was done in this laboratory.

From the peculiarity and isolation of our position on the Isthmus, many things were done by the Sanitary Department which in the United States are done by other branches of the Government, or by individuals. In the early days, when there was a great deal of fear and alarm on the Isthmus among the Americans with regard to health conditions, the Commission promised their American employees that all who died on the Isthmus should have their bodies returned to their

friends in the United States, at the expense of the Commission. The fulfilling of this promise was turned over to the Sanitary Department, and to carry it out, an undertaking department was established and attached to the laboratory. The expense of this department is one of the very many items that bear no relation to sanitation, merely because the officers of the Sanitary Department supervised the work, and the employees were carried on the rolls of this Department.

There being nothing else of this kind on the Isthmus, it gradually came about that whenever anyone died and his friends wished to have the body embalmed, we were called upon to do it, and in later years, as the non-employee population increased, there was a great deal of this outside work. Strange to say, in our rather complicated and involved accounts on the Isthmus, when the President of the Republic of Panama died, the Sanitary Department was called upon to embalm the body. The considerable cost of this operation, $100 or more, is charged to sanitation on the Isthmus, and while the Commission was a good deal more than reimbursed by the family from this expenditure, the reimbursement was not credited to sanitation, but went, under the law, to engineering and construction.

It seems all through as though the laws were framed with the idea of making sanitation appear

to have cost as much as possible, and the construction of the Canal as little as possible.

In a former chapter I stated that when we came down, in June, 1904, we purchased in New York and took with us $50,000 worth of supplies. Among these supplies were a certain number of coffins. When they were unloaded on the dock at Colon, the fact was considerably commented on. Among these coffins were six metallic cases, of a quality much superior to the others. These metallic cases were piled by themselves. The Commission, the governing body at that time on the Isthmus, was composed of seven men, of whom six on that date were present on the Isthmus.

Major La Garde was superintending the unloading of the ship. One of these six commissioners happened to be passing at this particular time, and he was very much impressed by what he saw. Stepping up to Major La Garde, he said: "Doctor, why do you bring six caskets of so much better kind and quality than the ordinary coffin?" Major La Garde promptly replied: "Mr. Commissioner, you know that Commissioner Blank is not on the Isthmus, and that only six commissioners are down here." The inference was so obvious that the Commissioner is said to have returned home and to have taken to his bed at once. I am glad to say, however, that none of the Commission ever had any use for those caskets.

CHAPTER XVII

MEDICAL AND SURGICAL SERVICE OF ANCON HOSPITAL

THE medical and surgical service of Ancon Hospital rapidly developed so as to win the confidence of the civil population all around. Not only did patients come to us from the Zone and the Republic of Panama, but patients also applied for admission, and many of them, from the west coast as far south as Chili, and as far north as Mexico. Many hundreds of people who formerly went to Europe and the United States for surgical care and treatment, now go to the Ancon Hospital.

The charges for this treatment are so arranged that it costs the Commission nothing, but is actually a source of considerable profit. Hundreds of patients who can never hope to have means enough to go to Europe or the United States for medical or surgical relief, are able to go to Ancon and pay the very moderate charges there.

This is another item of peculiar charge on the Isthmus. If it costs $30,000 a year to care for

these patients, in our accounts this $30,000 is charged to sanitation, but the $50,000 which the Commission receives for these patients is not credited to sanitation, but to construction and engineering.

An eye department was also established at Ancon by Major Theodore C. Lyster, of the United States Army, and was equipped with all modern appliances for eye, ear, nose and throat work. This department developed along the same lines as did the surgical work of the hospital, and was soon attracting patients from all the west coast north and south of us.

The hospital also had a well-appointed department for the insane. This grew from very small dimensions to considerable size. In 1913, we had two hundred and fifty patients in this section of the hospital. When we first went to Panama, the insane of the Republic were very poorly cared for. In most parts they were confined in the jails, and cared for with the ordinary prisoners. Knowing that, as time went on, we would have a considerable number of insane from the people in the Zone for whom we had to make provision, we proposed to the Panaman Government that we should take care of their insane in our institution, at a per capita cost of seventy-five cents per day. This they readily agreed to, and at present, considerably more than half of these two hundred and

fifty patients are sent in by the Panaman Government.

The cost of caring for these Panaman patients was charged to the Department of Sanitation, but the seventy-five cents per day which was received by the Isthmian Canal Commission from the Panaman Government, was turned over to the construction of the Canal.

A large and well-equipped laundry was attached to Ancon Hospital, furnished with all modern appliances. It was originally intended merely to do hospital work, but it was so difficult for employees to get washing done that the functions of the laundry were gradually extended and work was done for Canal employees other than those sick in hospitals. A reasonable charge was made for this outside work, and it finally came about that the income from this outside work went a considerable way in paying the expenses of the laundry.

Under Colonel Mason, who succeeded Colonel Phillips in the management of the hospital, the waste fats and tallow from the kitchen were saved, and enough soap made not only to supply the laundry, but in good part to supply the hospital.

The amount of surgical work in this hospital was very large, and the quantity of surgical dressings enormous. A considerable portion of these surgical dressings were not at all soiled, or very

little so. Colonel Mason had these picked over, washed and sterilized, and found that he could thus make a large saving in his surgical dressings.

In the early years of the hospital we bought such milk as we could get from the surrounding country at one dollar and twenty cents a gallon. Colonel Phillips brought cows from the United States and established a dairy on the hospital grounds, which accommodated about one hundred cows. After the dairy was well under way, he found that his milk cost him only from thirty to forty cents per gallon.

I merely mention these items to show how much can be saved by care and attention to details in a large institution like Ancon Hospital. I could mention many other items, but these suffice to show that the hospital was very economically as well as efficiently run.

All the adjuncts of a large and well-managed farm could be found on the Ancon Hospital grounds—a poultry yard, a piggery, a large garden, all of which contributed largely to the comfort of the patients, and to the economy of administration. The poultry yard contained some two thousand hens; also, pigeons, ducks, etc.

Ancon being in the suburbs of the city of Panama, and on the mountainside, was always considered a most desirable place of residence. Out of compliment to the Church, the French Company

erected for the Bishop of the Diocese of Panama a residence just within the hospital gates, and fixed up the approaches to this residence in very handsome style. A macadam road led from the hospital gate up to the front of the building, and a broad flight of some thirty-five or forty steps led from the main roadway directly up to the building itself. A noble row of fifteen or twenty royal palms partially screened the building in front. This building was used by us as quarters for the superintendent of Ancon Hospital.

The laboratory for original research, which I described above, was located across the roadway some fifty or sixty yards in front of this house. I have also mentioned that part of the function of the laboratory was that of an undertaking establishment, and many of the funeral services for those who died took place in a small chapel connected with this laboratory. At one time in the early days when a number of the Americans were dying of yellow fever, the Governor of the Zone, like many of the others one day felt cold chills creeping down his spine. He went over to the laboratory to consult Major La Garde. The Major took his temperature, felt his pulse, made a careful examination and looked exceedingly grave. He insisted upon the Governor's going up into his (Major La Garde's) house, the one I have just described as overlooking the laboratory.

While the Governor was undressing and getting ready for bed, a hearse drove up to the laboratory, but from the location of the building, the hearse was also immediately at the foot of the broad flight of steps leading to the Bishop's house. The Governor was naturally much depressed at the turn affairs seemed to be taking. Evening was drawing on, and the sun was sinking to rest. He knew from the history of yellow fever that many a poor fellow who had gone to bed as he was doing had not lived to see the sun rise again. So he made up his mind that he would take one more look at the sun, the trees and the outside world before he turned in. He went to the window, drew aside the curtains and looked out, and there at the foot of the steps, right at his front door, stood the hearse. With a groan he turned to his bed, sure now that Major La Garde regarded the case as one of those short and fatal ones, and had ordered the hearse so that it would be on hand and convenient when the Governor had need of it. But I am glad to say that the Governor was all right next morning, and the hearse had been ordered not for the Governor, but for some poor fellow in the morgue at the laboratory. This is not my story, but the Governor's, and I wish I could tell it in the inimitable way I have many times heard it from him.

As stated previously, any sick employee was

cared for in Ancon Hospital, or any other Department hospital, free of charge. If he were on the gold roll, he was allowed pay for thirty days' sickness in each year. The gold roll practically meant white Americans, of whom there were about five thousand. The families of employees receiving more than fifty dollars per month were charged one dollar a day for treatment in the wards. If they asked for special consideration, such as private rooms, or private nurses, they were charged accordingly. No charge was made for surgical operations on members of the families of employees. If the employee received less than fifty dollars a month, a member of his family was charged only thirty cents a day in the hospital. Any person not an employee was charged two dollars per day for ordinary treatment in wards, and an additional charge for all extras, such as private rooms, special nurses, etc.

On October 31, 1913, we had in our hospitals three hundred and twenty-nine white employees, four hundred and forty-five negro employees, one hundred and ninety-nine white non-employee pay patients, and four hundred and fifty-six black non-employee pay patients.

The income of the Department from all sources during the calendar year of 1913 was about $250,000. This came principally from persons cared for in the hospitals.

CHAPTER XVIII

THE SANITARIUM AT TABOGA

PANAMA BAY runs straight south from Ancon mountain about one hundred miles. It is filled with a great number of islands, which are evidently the tops of mountains projecting above the surface of the water. One of these islands is Taboga, situated in the bay about twelve miles south of the city of Panama. It rises abruptly from the surface of the ocean about a thousand feet, and at the present time is very thoroughly cultivated, the principal product being pineapples which have a great local reputation for size and flavor. It was inhabited by the Indians when the city of Panama was first founded by the Spaniards, and the wealthy inhabitants of the city of Panama early made it a resort, as being pleasanter, cooler and more healthy than the mainland. The water was considered unusually pure, and the island had the reputation of not being liable to yellow fever.

THE SANITARIUM AT TABOGA

A quaint little village, Taboga, nestles on the beach at the foot of the mountain. This village is now some four hundred years old, and the church there is reputed to be about that age. A gruesome thing about the pretty little church is the fact that in the outer wall a human skull is imbedded in the masonry. A glass cover is placed over the front, and the skull can be plainly seen. I was told that this was the skull of one of the early padres, who had been a very good man, and to whom the people were greatly devoted. And when he died, they took this method of perpetuating his memory and showing their veneration.

For the reason that Taboga was considered so much more healthy than Panama, the French located there a sanitarium. It was very prettily situated outside the limits of the village of Taboga, and the grounds about the sanitarium had been beautified and improved by the French just as had the grounds of Ancon Hospital. In their sanitarium they could accommodate about one hundred people. We enlarged this institution, and made it a convalescent hospital of about one hundred and twenty beds, and patients were received here on the same terms as in our other hospitals. It has proved to be to us a most useful institution.

In the early days, the Isthmus had such a bad reputation for health that when an American got

sick, he became very much depressed and made up his mind that he was going to die, and usually determined that he would go back home to the United States if he ever again became able to travel. The island of Taboga had such a reputation for salubrity that we could generally persuade him, when in this frame of mind, to go to the convalescent hospital there until he was able to travel, or until his ship sailed. He usually improved so rapidly at Taboga that by the time a ship was ready to sail, he had gotten over his homesickness and depression. In this way a large number of useful employees were saved to the Commission.

I think the bay of Panama, looking north from Taboga, compares very favorably with the bay of Naples, and reminds one somewhat of that famous sheet of water. A most romantic dell leads up to the top of the mountain from the convalescent hospital. Down this dell runs the only stream of water on the island, fed by springs near the top of the mountain, by way of this ravine. When one has finally reached the crest of the mountain a thousand feet above the level of the sea, the view on all sides is superb. To the north the mouth of the Canal, defended by the fortified islands of Naos, Perico and Flemenco; the city of Panama, Ancon mountain, and in the distance the continental divide of Culebra. To

the south, the bay, extending some fifty or sixty miles, dotted with islands, large and small, and in the distance, the historic group of the Pearl Islands.

The trail referred to gave access to the dozens of small pineapple farms located on each side of the ravine. Just as the trail reaches the top of the mountain there are three or four crosses, locating an equal number of graves. Every fall, in September, the whole village of Taboga turns out and has a religious procession which goes up to these graves and decorates them. The tradition among the natives is that when Sir Henry Morgan captured old Panama in 1670, he sent an expedition down to Taboga. The townsmen made a very brave resistance, but were slowly driven back by the pirates up the trail to the top of the mountain, where they made their final stand, and at last succeeded in beating off their enemies. The little burying-ground was the point where they made this stand, and the townsmen who were killed in the fight were buried where they fell. The yearly religious ceremony which I saw was kept up in commemoration of their brave fight.

The bay north of Taboga is pretty well inclosed by the mainland on the northeast and west, and Taboga on the south. This piece of water is a favorite place for the collection of large schools

of fish, and when these schools are in, all species of birds and fish follow in innumerable myriads. It is a very interesting sight to stand on the gallery of the convalescent hospital and see the thousands of pelicans and other species of birds diving and plunging after their prey. This is also a favorite nook for whales. I recollect on one occasion seeing as many as six in this little bay at the same time. They did not seem to be particularly shy, allowing us to approach them in the steam launch to within twenty-five or thirty yards.

This bay was the scene of one of the most remarkable naval battles of history. About ten years after Sir Henry Morgan's sacking of Panama, another buccaneering expedition crossed the Isthmus. They struck the South Sea about opposite the Pearl Islands, camping on the bay of San Miguel. Here they collected enough Indian dugouts to carry their force of three hundred men. This Indian dugout is very much like the one made by our Indians in the southern states, an exceedingly unstable and easily capsized boat, as anyone knows who has ever attempted to navigate one. It is much better adapted to the smooth inland waters than to the rough open sea. The Pearl Islands are about forty miles south of Taboga, and Sharp, with the bulk of his men, undertook a foraging expedition

to these islands. Hawkins with sixty men went northward along the coast toward the city of Panama.

When they reached the island of Chepo, they heard that the Spanish fleet was anchored at Taboga. Chepo is easily visible from Taboga. The Spanish fleet consisted of the flagship, the *Santa Maria,* whose armament was twenty guns, and whose crew consisted of one hundred men. She was accompanied by two tenders of a couple of guns each, and crews of about thirty men. Hawkins, having accurate information of the armament and strength of the Spaniards, wished to be reënforced by the main body before going any further. After waiting several days, he thought it unwise to delay any longer, and determined to attack the Spaniards with the force he then had—sixty men. So he started his canoes paddling toward Taboga, some fifteen miles off. When the Spaniards discovered the buccaneering fleet approaching, they got under sail, expecting to have no difficulty in running down and sinking in the open sea the canoes of the buccaneers.

Now the buccaneer, like our frontiersman, was dependent upon his gun for his food. Most of them had spent many years hunting wild cattle in Haiti, and the cured beef of cattle killed in this way was their principal support, and also their principal article of export and commerce,

under the name of "buccan." And this is how they got their generic title of buccaneer, a person who produces buccan. This wild life on the coast caused them to become equally expert in handling the dugout.

Ring Rose commanded the leading division of six canoes, and described the fight most graphically. As the large Spanish vessel bore down upon the canoes of the buccaneers, under full sail, the latter found no difficulty in avoiding the big vessel by a few strokes of the paddles. As the great ship passed, the expert marksman in the canoe shot down the man at the wheel. This caused the big ship to yaw, lose headway and become stationary.

The buccaneers in the same way would shoot down any other man who tried to get hold of the wheel, and so the vessel was unable to get under sail again. With the vessel stationary, it was very easy for the canoes to lie close in out of range of the big guns, and the superior marksmanship of the buccaneers, with their small arms, enabled them to keep down entirely small-arm fire from the *Santa Maria.* Here they lay all day, picking off any Spaniard who dared show himself. When evening came, the Spaniards surrendered. Ring Rose states that when he boarded the *Santa Maria* to accept the surrender, of the one hundred men of the crew who had commenced

the fight, ninety-two had been shot down, and only eight were left standing. Everyone of these eight was, however, wounded.

I call it one of the most extraordinary naval battles of history, from the fact that sixty men in dugouts, armed only with small arms, were able in the open sea to capture this man-of-war and her tenders, having an armament of over twenty great guns, and crews of over one hundred and fifty men. And this was accomplished not by surprise or stealth, but in an open, stand-up fight. The Spaniards saw them coming for miles, and sailed out to meet them.

The *Santa Maria* had, under the pirates, a most extraordinary history for three years. She sailed up and down the west coast, bidding defiance to anything the Spaniards sent against her. She finally doubled the Horn, reached the Barbadoes, and was there sold by the pirates for a good round sum.

CHAPTER XIX

THE LEPER COLONY

ANOTHER sanitary precaution that the Health Department determined upon was the segregation of the lepers. The Republic of Panama required by law the segregation of these people, but the community had been so poor for so many years that it was unable to bear the expense of any careful enforcement of this law. Some twelve or thirteen lepers had been living in huts down on the bay for a number of years, supported by the charity of such individuals as, moved by pity, could afford it. This burden for a long time before our arrival had fallen entirely upon Mr. Espinosa, one of the leading citizens of Panama.

Knowing that we would have a certain number of lepers in the Zone, we made the same proposition to the Panaman Government with regard to lepers that we had made with regard to the insane; that is, that we would care for their lepers

at the rate of seventy-five cents per day per capita.

We established a colony on a beautifully located peninsula running out into the bay of Panama, and almost as much isolated as if it were on an island. Here they could have their gardens, chickens, fruit-trees, etc. The location is naturally one of the prettiest on the bay.

We now have there some fifty lepers, who are living contented and happy. We have a white male trained nurse in general charge; a white female trained nurse in charge of the women, and some four or five other employees. We have a teacher for the children, and the lepers are always employed for any work of which they are capable, and are paid for this work so as to encourage them to seek it.

Dr. Henry R. Carter devoted a great deal of time and attention to the establishment of this colony, and it was due to his painstaking personal care that the matter turned out so successfully.

The history of the spread of leprosy is peculiar in that those who live with lepers in institutions and are constantly in contact with them do not as a general thing contract the disease. I refer to such people as doctors, nurses and attendants. On the other hand, people who have never known of any contact with a leper sometimes develop the disease. Such a case was that of the English

Consul, about 1850, who found himself with symptoms of leprosy, without, as far as he knew, ever having come in personal contact with a sufferer from this disease.

On one of the smaller islands of the bay, Flemenco, there was an old Spanish fort, which had been long unoccupied—not a very large work, intended to contain a garrison of some thirty or forty men. Just behind the fort was a pretty, cool, clean spring, which at some period long passed had been walled up and covered in for the use of the garrison. The island of Flemenco is at the mouth of the present Canal, and rises some three hundred and forty feet above the surface of the water. It is at present being fortified for the protection of the Canal. The English Consul, when he found he was a leper, determined that he would never return home, bought Flemenco Island, fixed up the old fort comfortably as a residence for himself, and there, with a few faithful attendants, he spent the rest of his life, a voluntary prisoner, and there he died and was buried.

A few hundred yards north of Flemenco was the scene of another naval battle during the revolution of 1903. The Government forces in the state of Panama under General Alban had brought the country into subjection to the federal government of Colombia. The rebels still had a gunboat, manned and equipped, lying at

Taboga. General Alban, the governor, seized one of the merchant steamers lying in the harbor at Panama, armed her, put a crew aboard with a considerable number of soldiers, and determined to attack the smaller rebel gunboat.

He sailed down to Flemenco Island, where he anchored for the night. During the night the rebel gunboat came up under the shelter of Flemenco Island. As day broke she steamed out from behind Flemenco; ranged herself along the stern of Governor Alban's ship where no guns could bear upon her, but where all of her broadsides could bear upon the Government ship, which had no steam up, and which could not, therefore, maneuver.

The rebel commander called upon the brave old Governor to surrender, representing that he was entirely at his mercy, but this the Governor refused to do. The rebel ship then opened fire, and continued to fire without any possibility of injury to herself, until the Government vessel was sunk. The survivors reported that Governor Alban and most of his men were killed by the hostile fire before the ship went down. For many years the masts and upper works of this vessel could be seen at low tide projecting above the water.

CHAPTER XX

QUARANTINE SYSTEM

PANAMA, from its situation and location, was peculiarly liable to infection from other places in both North and South America. It was the gateway through which a large traffic passed, and through which a continuous stream of travelers had been entering and departing for the previous four hundred years. After we had once freed it from yellow fever, it was very important that we should keep it free, and to do this we had to take such measures as would prevent a person in the early stages of yellow fever coming into Panama, and infecting the mosquitoes there, and thus starting an epidemic.

It was possible, also, for a ship to come into a port with infected mosquitoes aboard. These infected mosquitoes might escape to the shore and in this way start the disease, or they might bite some non-immune visiting the ship, and cause this non-immune to develop yellow fever at his

house in from three to six days after he had visited the ship.

To protect ourselves against the introduction of yellow fever in the above ways, quarantine regulations were established. Any ship that had developed a case of yellow fever aboard was considered infected. We knew that if the case were developed aboard, she must have had infected mosquitoes there which had bitten the patient and caused the disease. The ship was, therefore, fumigated in such a way as to kill all mosquitoes. After she had been fumigated, we considered her safe. But though the ship could be rendered safe by the fumigation, some of the passengers or crew might have been bitten by the infected mosquitoes just before the fumigation of the ship, and such person might develop yellow fever during the succeeding six days. We therefore took all the non-immunes to our quarantine station, and kept them for six days. At the end of six days we allowed them to return to the ship. The vessel itself, with all the immunes aboard, was released from quarantine as soon as the fumigation had been completed.

As I have said before, a person who has once had yellow fever is not liable to a second attack. Such person is known as an immune. To prove immunity, a passenger or member of the crew was required to present a written statement from

some recognized authority stating that the writer knew that the person under consideration had suffered from an attack of yellow fever.

Wherever yellow fever is endemic, it is a well-recognized fact that the native of the endemic area is not subject to this disease. This is explained on the theory that he had a mild attack in childhood, which, though not recognized, gives him protection in after life. This statement may strike one with surprise at first. We have, however, an exactly similar state of affairs among cattle. The beef native to a Texas fever region does not suffer from the disease, but an animal brought from anywhere outside this region always contracts the disease, and generally dies. The calf of the native cow is believed to have a mild attack which does not make it seriously sick, but protects it from Texas fever all through life. If the calf of the foreign cow is born in the endemic area, it seems to survive just as does the native calf, though the mother may have died of Texas fever.

An adult human being frequently has yellow fever in so mild a form that it is not recognized as yellow fever. Many Europeans are found in a yellow-fever endemic center such as Havana, who have lived there for years and not had yellow fever, as far as they themselves were aware. If, therefore, an individual could prove that he

had lived for ten years continuously in a yellow-fever center, his immunity was accepted by the quarantine authorities.

If a ship had touched at a port where yellow fever prevailed, before coming to Panama, there was a possibility of infected stegomyia having gotten aboard, even though no cases of yellow fever had developed on the ship. For by chance the infected mosquitoes may not have bitten anyone, or if they had bitten persons on the ship, the biting may not have taken place a sufficient length of time for the development of the disease, before the arrival of the ship at Panama. Such a ship was considered as possibly infected, and was treated at quarantine exactly in the same way as above described in case of a ship known to be infected.

The fumigation of a ship was generally accomplished by burning sulphur, as above described in the case of fumigating a house. In the parts of a ship, such as the engine-room, where there was valuable machinery which would be injured by sulphur fumes, pyrethrum was used, just as in similar circumstances it was used in fumigating dwelling-houses. We had more elaborate machinery than the pots and pans described in the fumigation of houses, with which sulphur fumes could be developed much more rapidly and in much larger volume. This was used by us on

special occasions where its use seemed desirable.

In the history of yellow fever, many curious cases of ship infection from this disease have occurred. During the fall of 1904, one of our warships, the *Boston,* spent several months in Panama Bay. While down the coast on gun practice, in January, 1905, she developed seven cases of yellow fever. She had been away from Panama such a length of time that the doctor knew that the cases must have received their infection aboard, and that therefore the ship was infected. The cases were well marked and most of them were severe, the doctor and one of the men dying of the disease. Nothing could be found in the sick records of the ship which would indicate that anyone belonging to the ship had contracted yellow fever ashore and developed a mild case, and thus infected the ship. All the cases were connected, directly or indirectly, with the wardroom, three of them being commissioned officers. As we were having at the time some yellow fever in Panama, the crew had not been allowed ashore. One or two of the officers, only, had been permitted to come into Panama for the transaction of necessary business.

A short time before the ship had left the harbor, New Year's Eve, 1904, they had given a ball aboard, which had been attended by a large number of the citizens of Panama. After a careful in-

vestigation of the matter, we concluded that some one of these persons was in the initial stages of a mild case of yellow fever. It is quite possible for such a person to be up and around without appreciating that he has the disease. This person, we concluded, was bitten by some of the stegomyia aboard. At the end of two weeks these stegomyia became infectious and gave the disease to the crew.

Dr. G. A. Perry, of the Public Health Service, who had immediate charge of the work, found a small flat tub under the steps going down from the wardroom, in which stegomyia were breeding freely. This was the only place on the ship where larvæ were found, and this one piece of carelessness was responsible for the epidemic on the ship. All the mosquitoes aboard ship undoubtedly bred here. We could never find out why this tub was kept here, as the wardroom steward who was responsible, contracted the fever and died. The surgeon of the ship also died.

The ship was carefully fumigated, under the supervision of Dr. Henry R. Carter, and no more cases occurred, though the ship immediately went to sea with all of her crew aboard, with the exception of the sick, who were brought to Ancon Hospital.

As an instance of what a man sick with yellow fever may do in the way of going about, I will

narrate here the case of one of our patients which will well illustrate this point.

An American machinist, coming from San Francisco to Panama, got off the steamer at Corinto, Nicaragua, got on a spree and was locked up in the Corinto jail. He was left there by the steamer, but was released from jail in time to catch the next steamer going to Panama. He reached Panama at the end of five days, went to work for the Commission, and worked one day, but being taken sick, he quit work, though he did not report to the doctor. Instead, he again commenced drinking. On the second day of his disease, he was arrested by the Panaman police, and placed in jail as being drunk and disorderly. He was released on the third day of his disease and continued his debauch. He was again arrested on the fourth day, put in jail, and was then discovered by one of our inspectors who recognized that he was sick as well as drunk. He had him brought to Ancon Hospital, where he died on the sixth day from the beginning of his attack.

The symptoms of the disease were well-marked, black vomit being profuse. An autopsy confirmed the diagnosis. Here was a man suffering from a case of yellow fever, of which he finally died on the sixth day, who, for the first five days of the disease, was about town, going from saloon to saloon, drinking immoderately, eating what

came to hand, and sleeping where convenient. Twenty-four hours before he died, he rode up to the hospital in a cab and walked into the ward. He was having black vomit before he left the jail.

It is often extremely difficult to trace a case of yellow fever and discover the source of infection. In 1909 we were very much startled by what appeared to be a case of this disease, which had apparently been contracted in the city of Panama, and developed there.

A young Englishman had boarded the Royal Mail steamship at Southampton, bound for Colon. While the ship had touched at several points en route, the Captain certified that no one had left the ship at Cartagena, the only infected port at which she had touched. He arrived in Panama January 6, and after being in Panama six days, he developed yellow fever, of which he died on January 24. The symptoms were well marked, and an autopsy confirmed the diagnosis.

As far as we knew, there had not been a case of this disease in Panama for four years, and the stegomyia were so scarce that we did not believe that yellow fever could be transmitted. The poor fellow, just before he died, told Dr. William Deeks, his attending physician, that on the night during which they were anchored in the Bay of Cartagena, the first mate and himself had slipped off unobserved in one of the ship's boats, spent

the night in Cartagena, and had gotten back to the ship before daylight. This confession at once cleared up the case. He had evidently been bitten by a stegomyia mosquito while in Cartagena. Had it not been for his confession, the evidence would have been very strong that in some way the disease had been contracted in Panama.

During 1899 we had the most curious case in Havana of infection in the person of a nun, Sister Maria de los Angeles, a Dominican nun, and a native of France. She had come direct to New York from Europe, on the steamship *Celtic,* remained there two days, and then took the Ward Line steamer *Vigilancia* for Havana. The trip from New York to Havana by this steamer occupies four days.

The nun reached Havana September 8. She was feeling badly, though she did not give up her duties on that account. On September 11 she was taken sick with a chill, and died with well-marked yellow fever on the sixteenth.

The circumstances were such that the Board was convinced that she had contracted the disease on board ship, and not in Havana. She must have gotten it in some way between New York and Havana. She could not have been infected in New York, as there had been no yellow fever there during the preceding twenty years. The steamer under discussion plied between Vera Cruz, Mex-

ico and New York City, touching at Havana both going and coming.

We found that the records of the ship showed that the last case of yellow fever aboard had occurred on the second trip before the one under consideration, antedating the time the nun was aboard by about a month. This was in the person of a passenger from Vera Cruz, who was taken off at the quarantine station at New York. He occupied the stateroom that afterwards was occupied by the nun on her trip to Havana. Such an instance twenty years before would very readily have been explained as an instance of infection from the room, but we now know that yellow fever can be contracted only through the bite of an infected female stegomyia mosquito. No other case had occurred on the ship during the month following this case, in the passengers from Vera Cruz. It is probable, therefore, that a stegomyia mosquito in this room must have bitten the passenger sick with yellow fever during the trip up to New York; that this mosquito remained in this room for nearly a month, biting the unfortunate nun soon after she got aboard.

As no other cases occurred afterwards, it is quite probable that the nun killed the mosquito at the time of the biting. It is also probable that some immune occupied this room on the trip up from Vera Cruz to New York City, who would

not be injured even if the mosquito bit him. On the preceding trip down from New York to Vera Cruz the person occupying the room would not have been injured by the biting of the mosquito, even if the person had been a non-immune, as the mosquito requires two weeks from the time she bites a yellow-fever patient before she herself becomes infectious. The preceding trip down was within this two weeks' period of non-infectiousness in the mosquito. At first blush, the case certainly appeared very mysterious. How was it possible for a person coming from France via New York to Havana, to have yellow fever when she reached Havana!

In 1904, when we first reached Panama, yellow fever surrounded us in all directions. Guayaquil, Ecuador, on the west coast of South America, three days' sail from Panama, was badly infected. On the west coast to the north, Corinto in Nicaragua and other ports, we knew to be infected. On the Caribbean Sea, within from one to three days' sail, Cartagena, Colombia, Porto Caballo, La Guira, Venezuela, the port of Caracas, and other ports were having yellow fever. On the Gulf of Mexico, Vera Cruz, Mexico, was an endemic center. Progreso, the capital of Yucatan, was also having this disease. In 1905, New Orleans, Louisiana, had a sharp epidemic of yellow fever. With all these places we had frequent and close commercial

relations. In 1906, Cuba had some yellow fever at many points. All these places had to be carefully guarded against by our quarantines.

Bubonic plague existed endemically at Guayaquil, and several other ports on the west coast of South America, and this disease occurred sporadically at ports on the Caribbean Sea and the Gulf of Mexico. Quite a number of cases of plague developed in New Orleans during 1914. Our quarantines had to look after this disease in the same manner that yellow fever was guarded against.

I have already mentioned that in 1905 plague established itself at La Boca and Ancon, in spite of our quarantines. This is no reflection upon our quarantine system. I am glad to say that under the administration of Dr. Henry R. Carter and Dr. James A. Perry, our quarantines were as efficient as could be found anywhere, but the very best quarantine will at some time allow a case of infectious disease to pass. Such accidents cannot be entirely prevented, except by the entire abolition of commerce.

For the care of passengers and ships under quarantine, we built two quarantine stations, one at the north end of the Canal on the Caribbean Sea, the other at the south end on an island in the bay of Panama.

Culebra Island, on which was located the Pan-

ama quarantine station, is an island of four or five acres in extent, the center of the group of islands on which are now located the fortifications protecting the southern mouth of the Canal. These islands are mountain tops projecting from fifty to three hundred and fifty feet above the surface of the waters of the bay of Panama. They are heavily wooded, and are very picturesque in appearance. They are now connected with each other and with the mainland by an artificial causeway, built during the period of Canal construction by dumping here the spoil from Culebra Cut.

On Culebra Island, nine or ten comfortable and substantial frame buildings were erected, capable of caring for some three or four hundred persons. They consisted of two small hospitals, divided so that five or six different kinds of contagious diseases could be cared for, if necessary, at the same time; a large barrack building with a capacity of two hundred beds for the care of steerage passengers, divided into a male and female side; a large building of a capacity of seventy-two beds, for the care of first and second-class passengers, divided into small wards and rooms for the separate care of the two classes of passengers; another large building for the housing of the employees of the station; a smaller building for the dispensary, doctor's office and administration,

and a comfortable residence for the doctor and his family.

The station was well equipped for making the different classes of passengers comfortable, and for the care of the sick. In connection with the station we kept equipped a self-propelling barge of about one hundred tons capacity. This vessel was named the *Walter Reed,* and was supplied with modern machinery for generating sulphur fumes and pumping these fumes aboard the ship to be fumigated.

These islands are about three miles from the mainland. There was no more desirable place about Panama in which to spend a week than the quarantine station. The site was as picturesque and attractive as could be desired, and its location, three miles out in the bay, made the temperature cool and agreeable. I have to confess that, as a general thing, the passengers quarantined at Culebra did not appreciate its beauties and comforts sufficiently to stay an hour after their quarantine period. One of our ministers, however, coming up the west coast with his family, was held at the quarantine station for several days, in order that his quarantine period might be completed. When the time had expired, he came to the city of Panama, took a look around, remembered the beauty and comfort of Culebra Island and the quarantine station, and concluded that he

would like to take his family, return to the island, and stay there until his ship sailed. This we gave him permission to do, and he and his family remained at Culebra about a week after his quarantine period had expired. This established the reputation of the Panama quarantine as being a salubrious, delightful and desirable place in which to be detained.

CHAPTER XXI

MEASURES AGAINST BUBONIC PLAGUE

IN 1906, when our malarial rate was highest, we had eight hundred out of every thousand of our employees admitted to hospitals on account of malaria. In 1913 we had only seventy out of every one thousand of our laborers admitted for this disease. The yearly table for malarial rate is as given below:

1906	821	per 1,000
1907	426	" 1,000
1908	282	" 1,000
1909	215	" 1,000
1910	187	" 1,000
1911	184	" 1,000
1912	110	" 1,000
1913	76	" 1,000

Yellow fever was entirely eradicated. In 1904 we had a few cases, and in 1905, a sharp epidemic. In November, 1905, the last case occurred in the city of Panama, and in May, 1906, the last case in

the town of Colon. Since that time no cases have originated on the Isthmus.

On June 20, 1905, Nehemiah Morgan, a Jamaican negro, employed at La Boca, the southern terminus of the Canal, was admitted to the hospital with symptoms of bubonic plague. The name La Boca has since been changed to Balboa. This man died on June 23, and the autopsy confirmed the diagnosis. On the twenty-sixth, a quarantine was placed against La Boca. Dr. James Perry, of the United States Public Health Service, was placed in charge. He was supplied with a force of four foremen and one hundred laborers, who under his direction did the necessary cleaning and fumigation. This quarantine was kept up until July 15, when it was raised, as there was no further indication of plague or plague-infected rats.

Dr. Perry deserves the greatest credit for the efficient way in which he managed to stamp out this infection, so threatening and dangerous to the work.

Plague is an infectious disease caused by a well-known germ, the bacillus pestis. It is a disease of the rat, and is transferred from the rat to a human being by the rat flea. Anti-plague measures are, therefore, almost entirely directed toward the destruction of rats. Rigid quarantines are also kept up, so as to prevent human beings

sick with the disease from going to uninfected places, and there starting new foci of infection.

The measures used against rats are poisons of various kinds, but the rat is one of the most intelligent of animals, and soon learns to avoid poisons. The same thing is true with regard to traps. Rats so rapidly learn about poisons and traps that some writers on anti-plague measures advise that these measures be used only during emergencies, when plague is either present, or there is imminent danger of an outbreak, the argument being that if you use these measures continuously, the rats will become so knowing that you cannot kill them when plague is upon you and they are actually infected.

Mr. Le Prince arranged a very successful rat-trap which killed the rat by short-circuiting between two electric wires. Such a trap placed in a rat runway gave no notice to the rat whatever, and always killed him. But it requires some skill to manipulate such a trap, and our Jamaican darkies were so often shocked in trying to arrange it that Mr. Le Prince gave it up.

Undoubtedly, the best anti-plague measures are those calculated to free the town from rats permanently, and these measures relate principally to rat-proofing the houses. In a general way, these measures consist in making a concrete floor, and in putting six or eight inches of concrete in the

wall around this floor. With the whole town fixed up in this way, you would have no rats. At the same time, disposal of garbage should be carefully looked after, with the object of limiting the food supply of rats.

Dr. Connor, of Colon, invented an excellent garbage stand, so arranged that a lid automatically closed the garbage can whenever the lid had been raised and released. If, however, a town has been made entirely rat-proof, that town is pretty secure from plague. If there are no rats there, no harm will be done, even if cases of plague come in, for there would be no means of transmitting it from man to man. If you have plenty of rats in a commercial city, such as Panama, in direct commercial relation with cities having plague, you are sure, in the course of time, to get in plague cases, no matter how good your quarantine, and if plague once gets in where there are plenty of rats it is very apt to spread.

CHAPTER XXII

THE WORK OF THE SANITARY DEPARTMENT OF PANAMA

THE work of the Sanitary Department of Panama has without question been a most useful adjunct in the construction of the Canal. It has enabled this work to be carried through with a minimum of loss, both in regard to sickness and death among employees engaged in construction work in the Canal Zone. We have no means of telling what was the sick rate with the French during the period of construction under the old French Company, from 1881 to 1889, but we know that it was very large.

Our Army in Cuba during the Santiago campaign had during the last two months of our stay there a constant sick rate of over six hundred per thousand. Undoubtedly, the French rate approximated this during their period of active work, and we can safely calculate that their constant sick rate was at least three hundred and thirty-three per thousand, or one-third their force.

Our force during the ten years of construction averaged thirty-nine thousand men. If we had had a similar constant sick rate, we should have had thirteen thousand sick employees in our hospitals every day during the ten years of construction. As it was, we had only twenty-three per thousand sick each day, a total of nine hundred for the whole force; that is, we had about twelve thousand fewer men sick every day than had the French. This twelve thousand men per day saved from sickness must be credited to the sanitary work done on the Isthmus.

Now let us consider the totals: We had an average of 900 men sick every day. For the year, this would give us 328,500 days of sickness, and for the ten years 3,285,000 days of sickness. If our rate had been 300 per 1,000, a very moderate figure compared with what it was under the French, we should have had 11,700 sick every day. For the year, this would have given us 4,270,500 days of sickness and for the ten years, 42,705,000, a saving of 39,420,000 days of sickness during this period. This saving must justly be credited to sanitation.

It cost us about one dollar a day to care for a sick man on the Isthmus. The Commission cared for the sick free of charge. Every day, therefore, of sickness prevented on the Isthmus lessened the expense which the Commission had to bear by one

dollar. The Commission was therefore saved by this sanitary work, if we consider the whole ten years of construction, $39,420,000.

This represents only one phase of the saving due to sanitation, merely the saving due to decrease in the numbers of sick who had to be cared for. But the sanitary work really saved much more than this. If three hundred men out of every one thousand of our employees had been sick every day, the efficiency of the other seven hundred would have been correspondingly decreased. The other seven hundred would have been more or less debilitated, and more or less depressed, and the amount of work turned out daily by each man would have been considerably less than it actually was for the employee enjoying good health and cheerful surroundings. We should have had to pay considerably higher wages, if the Isthmus had continued to bear the reputation during our period of construction which it had always borne during the years preceding 1904; if, for instance, it had been known that three out of every ten men going to work on the Canal would be sick all the time, and that two out of every ten would die each year, and that the whole ten would be dead at the end of five years.

Great loss was caused to us in the first years on the Isthmus by the demoralization among the working force, and almost stoppage of work which

took place during periods of exacerbation in the yellow-fever condition, or when prominent employees died of that disease. Great loss also occurred to the French on this account. Mr. Bunau-Varilla described very graphically the condition of his force as the result of such conditions. Mr. Bunau-Varilla was one of the most prominent of the French engineers for the old French Company, and was their chief engineer from 1885 to 1887.

I do not think that anyone familiar with the conditions would question the statement that a larger sum in dollars and cents was saved to the Commission in these ways than was saved by the direct decrease in the number of sick.

Considering all these factors, it will not be considered an exaggerated estimate to state that eighty million dollars was saved to the United States Government by the sanitary work done on the Isthmus during the ten years of construction. That is, granting that the construction work could have been accomplished under such conditions as had existed during the construction period of the old French Company, or which existed on the Isthmus of Panama at any time prior to 1904, and granting that public sentiment in the United States would have allowed the prosecution of the work with such mortality among the laboring force as had previously occurred, it would have cost the United States eighty million dollars more than it

actually did cost to accomplish the results it has attained on the Isthmus.

I go into these figures to demonstrate that there is great financial profit resulting from money spent on such sanitary measures as we inaugurated on the Isthmus. This is the purely commercial side of the question. Of much greater importance is the moral argument that can be adduced from the saving of life and suffering that results from such measures.

During the ten years of construction, we lost by death seventeen out of every thousand of our employees each year. That is, from the whole force of 39,000 men, 663 died each year, and for the whole construction period we lost 6,630 men. If sanitary conditions had remained as they had been previous to 1904, and we had lost, as did the French, two hundred of our employees out of each one thousand on the work, we should have lost 7,800 men each year, and 78,000 during the whole construction period.

We therefore claim for the work of the Sanitary Department the saving of 71,370 human lives during the building of the Panama Canal. Where one man died, probably three would have returned home broken in health, with months and years of suffering and invalidism ahead of them. Sanitation on the Isthmus has saved this heavy toll to the devoted people engaged in this great work,

and was, therefore a most wise and lucrative investment to our Government, and played a most important part in aiding the construction work in that great enterprise.

But I believe that this aiding in the construction of the Canal is not the most important function that the sanitary work at Panama has played. The Canal Zone, for the past four hundred years, ever since it has been known by the white man, has been one of the most unhealthy spots in all the tropical world, and this fact has been generally known and recognized by all nations which have had any commercial importance.

About the time of the discovery of America, Europeans began to visit and colonize the tropics, but it was early discovered that the white man could not live and thrive with such conditions and surroundings as existed there. It seemed to be demonstrated that there was something in the climate that sapped his constitution and broke his health. This statement applies to white children to an even greater extent than to the adult.

The great colonizing nations had been the Spaniards, the Portuguese, the Dutch, the French and the English. Their experience had all been exactly similar from the beginning of the sixteenth century to the present time—that the white man could not live and thrive in the tropics, nor could he leave behind him in those regions a healthy

progeny. By all men everywhere it was believed that this was due to tropical climatic conditions, which could not be combated, and that therefore the white man was permanently barred from building up any great civilization in these regions.

Man, like all other animals, must necessarily have developed in one locality. If we accept the modern explanation, generally received by educated persons, Darwinism, all life at present on the globe must have descended from one single cell. If we take some individual animal at present living, a dog, for instance, we could trace his ancestry back to the first cell, if we could obtain all the facts in the case. By very slow changes, genus after genus and species after species developed from this first cell, each genus and each species differing slightly from the one preceding.

An individual varying very slightly from the other individual of his species, becomes the progenitor of a new species, provided the variation accords with his surroundings so as to fit him better for the struggle of life. But all of the new species must descend directly from the one pair which produces these favorable variations in their progeny. Every species, therefore, such as the dog, must originate in some one locality. If at any time this species of animal is found in all parts of the world, it must have slowly spread from the locality in which it originated. The dog,

therefore, came to his present development in some one part of the world. As he is now found in all parts of the world, he must have spread from this one locality in which he originated.

Exactly the same argument applies to man. If we consider man's condition in his earlier stages, we can see that there must have been a period when he had neither fire nor clothing. At this time he must have lived in parts of the world where the temperature was that now found between the tropics of Cancer and Capricorn. As we know him now, he could survive the year around without fire and clothing only within this region. He might live a little north and south of these parallels of latitude, but not very far. Very few individuals of a community which attempted to spend a winter in the latitude of Washington, without either fire or clothing, would be alive when the warm weather of spring returned. It is pretty certain, therefore, that man lived exclusively in the tropics, up to the discovery of fire and clothing.

There was a period, then, in man's existence when the environment found in the tropics was better suited to his life than that found in the present temperate zones. Conditions gradually changed, until affairs were exactly reversed, and the temperate regions became better suited for man's healthy life than the tropical regions. This

was the condition of affairs when we first begin to get some knowledge of man, at the early dawn of history. When we first begin to learn anything about him historically, the most vigorous and healthy races, mentally and physically, were to be found in the temperate zones. The conditions that brought about this change of habitat in man were probably the spread of the various infectious diseases within the tropics. The hot tropical regions were much better fitted for the life of the germs which caused these infectious diseases than were the temperate regions, for exactly the same reasons that these tropical regions better suited the life and development of man. Due to his superior intelligence and superior powers of locomotion, man was enabled to spread through and occupy the tropical regions long before the germs of the various infectious diseases were able to do so.

Yellow fever, for instance, was able to extend very little beyond the region where it originally developed, until man came along with his ships, and in this way enabled the yellow-fever germ to begin its travels about the world. As yellow fever developed in America, the germ did not begin its travels until Columbus brought his ships into the Caribbean Sea. As the infections spread through the tropics, the environment in those regions became unfavorable to man, to such an ex-

tent that he ceased to be able to improve in his mental and physical characteristics. But as the environment of regions outside the tropics was still more unfavorable, actually deadly, he had no escape.

At this period, then, man found himself inhabiting tropical regions where sanitary conditions, the infections, were very unfavorable to him, and he was unable to migrate to the temperate zones, because the sanitary conditions there, cold, were deadly to him.

About this time, two great sanitary discoveries, the most important ever made by man, namely, fire and clothing, came to the knowledge of our tropical ancestors. The greatest sanitarian that the human race has ever produced was probably the individual who discovered fire, and next in importance, the individual who first wore some kind of clothing. These two discoveries enabled man to overcome the hitherto insurmountable sanitary obstacle of the temperate regions, namely, cold. With the application of these two sanitary discoveries, the human race was enabled to migrate from the tropics and continue healthy development in the temperate regions.

At the present time, we have just reversed the process; we have just made sanitary discoveries that will enable man to return from the temperate regions to which he was forced to migrate

long ages ago, and again live and develop in his natural home, the tropics. These sanitary discoveries are those that have enabled us to control yellow fever and malaria.

The practical application of these great discoveries has just been demonstrated during the construction of the Panama Canal. This was not the first demonstration with regard to either disease. But the conditions were such at Panama that they have attracted the attention of the whole world, and probably the general knowledge that the white man can live and thrive in the tropics will date in future times from the construction of this great work.

A given amount of labor applied to land will produce a very much larger amount of wealth than will the same labor applied in the same way produce in the temperate regions. The white man, of all the races of the human family, is the most eager in his pursuit of wealth. As it becomes generally known that he can live in the tropics and maintain his health, necessarily a large emigration will occur from the present civilized temperate regions to the tropics. The largest areas of land suitable for cultivation lie in the tropics, and much the largest bodies of rich alluvial lands, such as the valleys of the Amazon and the Congo. Not only are these lands more productive than the lands of the temperate zone,

but climatic conditions enable the farmer to produce several crops a year. The tropics, when occupied and cultivated by the white man, will produce many times the amount of food now produced in the temperate regions.

The great civilizations of man are now already established and developed in the temperate zones of Europe and America, and it is probable that, for centuries to come, these great empires will be located where they are at present, and that the tropics will be the agricultural, food-producing regions from which these centers of civilization will be supplied.

In the early stages of the development of mankind it was all that each individual could do to supply his own necessities. As he advanced in civilization, he produced more than he himself needed, and thereby had a surplus to exchange with his neighbors for things which he desired. As his productive capacity increased, a larger number of men were enabled to apply themselves to the arts and sciences. The degree of civilization to which a community can reach is in the main governed by the amount of the necessities of life that the labor of one man applied to the land can produce. If one man's labor can produce enough of the necessities to support himself and one other man, we have a certain degree of civilization and refinement. If his labor produces

enough to support himself and two other men, a higher degree of civilization results. In the tropics one man's labor applied to natural opportunities is able to support more men than the same amount of labor applied in any other part of the world. In the long run, therefore, the great civilizations of the future will be located in the tropics.

No doubt the great centers of civilization will remain for centuries much as they are at present. The white settlers will go to the valleys of the Amazon and Congo, building up large agricultural communities which will supply the European and American centers located as they are at present with their food supply. But in the course of ages the centers of civilization will move to where a given amount of labor will produce the largest amount of food. Of course, other things must be equal. I am assuming that the government in these new communities is as good as the government with which we are comparing it in the temperate zone. When this great migration of population has fully commenced, I believe that the peoples of that day will look back upon the sanitary work done at the Canal Zone as the first great demonstration that the white man could live as well in the tropics as in the temperate zone.

I am inclined to think that at this time the sanitary phase of the work will be considered more

important than the actual construction of the Canal itself, as important to the world as this great waterway now is, and will be for generations to come.

The discovery of the Americas was a great epoch in the history of the white man, and threw large areas of fertile and healthy country open to his settlement. The demonstration made at Panama that he can live a healthy life in the tropics will be an equally important milestone in the history of the race, and will throw just as large an area of the earth's surface open to man's settlement, and a very much more productive area.

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